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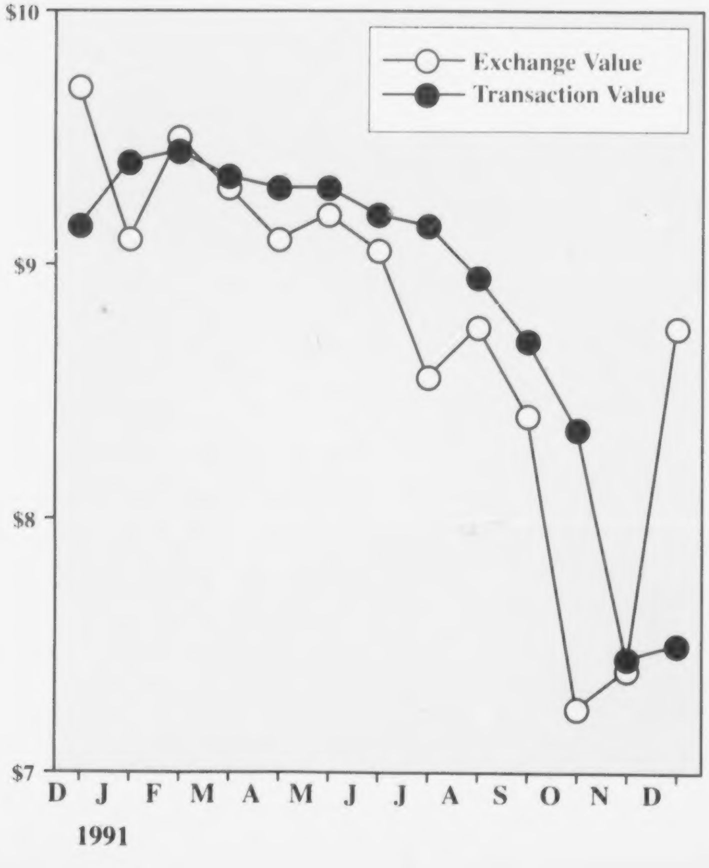
NUEXCO

1991 Annual Review



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1991 Annual Review

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To Our Readers

NUEXCO is pleased to present its *1991 Annual Review*. Each year the *Annual Review* requires the efforts of many CONCORD/NUEXCO professionals, without whose contributions the publication would be impossible. The editors appreciate their efforts and trust our readers will find the *Annual Review* informative and useful.

The following people made valuable contributions to the success of this year's Annual Review:

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MARKET DEVELOPMENTS

OVERVIEW

Few market participants accurately predicted the course of the uranium market in 1991. While most expected prices to remain relatively low, nearly all participants were surprised as prices fell below $8 per pound U_3O_8. In fact, as evidenced by a few transactions late in the year, prices even dipped briefly below $7 per pound. When adjusted for inflation, spot market prices were clearly at their lowest level ever. Uranium supply outstripped demand throughout 1991, and while specific events may affect the market temporarily, a sustained price recovery is unlikely until supply and demand come more into balance.

The Exchange Value began 1991 at its highest level for the year, with a December 31, 1990, Exchange Value of $9.70 per pound U_3O_8. The market declined fairly steadily during the first three quarters of the year, with brief surges in supply or demand creating only moderate volatility (**Table 1**). The record-low prices of October and market participants' reaction to the November filing of the anti-dumping petition against the Soviet Union, caused prices to jump temporarily to $8.75 per pound U_3O_8 on December 31, 1991, as sellers backed away from new sales. However, the continued presence of ample supplies, coupled with the fact that the outcome of the anti-dumping investigation would be delayed until at least mid-1992, resulted in prices dropping again, to $8.00 per pound in early 1992.

Table 1
1991 NUEXCO NATURAL URANIUM SPOT MARKET PRICE INDICATORS

Determined as of the Last Day of the Month	Published in Report Number	Exchange Value [1] (Per Pound U_3O_8)	UF_6 Value [1] (Per Kg U as UF_6)	Transaction Value [1]			
				Per Pound U_3O_8	Number of Transactions	Number of Months	Million Pounds Equivalent U_3O_8
January	270	$ 9.10	$27.50	$ 9.40	18	3	3.1
February	271	$ 9.50	$27.75	$ 9.45	18	3	2.6
March	272	$ 9.30	$27.50	$ 9.35	19	3	3.0
April	273	$ 9.10	$27.25	$ 9.30	22	3	5.6
May	274	$ 9.20	$27.60	$ 9.30	21	3	5.3
June	275	$ 9.05	$27.25	$ 9.20	24	3	6.3
July	276	$ 8.55	$25.75	$ 9.15	21	3	4.1
August	277	$ 8.75	$26.25	$ 8.95	26	3	5.9
September	278	$ 8.40	$25.50	$ 8.70	20	3	4.4
October	279	$ 7.25	$22.75	$ 8.35	22	3	4.6
November	280	$ 7.40	$22.75	$ 7.45	22	3	4.9
December	281	$ 8.75	$26.00	$ 7.50	26	3	8.0
Averages [2]		**$8.70**	**$26.15**	**$ 8.51** [3]	**22**	**3**	**4.8**

[1] Refer to the **Market Values Definition** in the **Index Section** for further descriptions.

[2] Simple arithmetic averages, except where noted.

[3] Volume-weighted annual average.

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Table 2
1991 NUEXCO EXCHANGE VALUE EXPRESSED IN SELECTED CURRENCIES[1]

Country (currency)	(Per pound U_3O_8 as Concentrates)					December 31, 1991 Relative to December 31, 1990
	December 31, 1990	March 31, 1991	June 30, 1991	September 30, 1991	December 31, 1991	
Australia (dollar)	12.58	12.00	11.81	10.51	11.51	- 8.5%
Belgium (franc)	299.57	326.43	337.31	287.97	273.69	- 8.6%
Canada (dollar)	11.25	10.77	10.33	9.50	10.11	-10.1%
EC (ecu)	7.17	7.75	7.98	6.82	6.53	- 8.9%
Finland (markka)	35.13	37.48	38.81	34.06	36.15	+ 2.9%
France (franc)	49.32	53.68	55.55	47.63	45.33	- 8.1%
Germany (mark)	14.50	15.86	16.39	13.97	13.26	- 8.6%
Italy (lira)	10,922	11,805	12,182	10,456	10,040	- 8.1%
Japan (yen)	1,309	1,314	1,246	1,116	1,092	-16.6%
The Netherlands (guilder)	16.35	17.88	18.47	15.75	14.94	- 8.6%
South Africa (comm. rand)	24.88	25.40	26.13	23.56	23.99	- 3.6%
South Korea (won)	6,931	6,749	6,555	6,111	6,639	- 4.2%
Spain (peseta)	927.79	983.09	1,028	885.80	845.08	- 8.9%
Sweden (krona)	54.56	57.27	59.19	51.00	48.42	-11.3%
Switzerland (franc)	12.38	13.52	14.06	12.18	11.87	- 4.1%
Taiwan (dollar)	258.36	250.36	242.81	220.08	223.12	-13.6%
UK (pound)	5.04	5.34	5.57	4.80	4.68	- 7.1%
US (dollar)	9.70	9.30	9.05	8.40	8.75	- 9.8%

[1] As of May 1991 Report #273, calculated using currency exchange rates **for** the last business day of the month, as published in *The Wall Street Journal*. Prior to May 1991 Report #273, calculated using currency exchange rates published in *The Wall Street Journal* **on** the last business day of the month.

Most spot market activity occurred in the range of $7.50 to $9.00 per pound during 1991. This represented a shift downward from 1990's wide trading range of $8.00 to $12.00 per pound. The narrowing of the 1991 price range can be partly attributed to the withdrawal of discretionary buyers, who reacted cautiously to any price movements, thereby reducing price volatility compared to 1990.

Market volume in 1991 lagged significantly behind the record 1990 level (**Table 3**). While the number of 1991 transactions concluded approached that of 1990 (112 vs. 118), 1991 volume fell short by ten million pounds equivalent U_3O_8. This is due to lower demand, the result of the record spot quantities purchased during 1990. Nevertheless, 1991 near-term market volume was still the third-largest on record, trailing only 1990 and 1989 levels. A major factor in the record sales figure of 1990 was the large volume of discretionary purchases made by both utilities and producers. In 1991, however, as prices continually dropped below expectations month after month, discretionary buyers became more cautious, each trying to anticipate a market bottom. As a result of this caution, when buyers did make discretionary purchases, the transactions usually involved smaller quantities.

Competition among sellers was active in 1991. Unlike 1990, when periods of low market prices caused all but a few suppliers to withdraw from the market,

Table 3
NEAR-TERM URANIUM SALES [1]
1990 versus 1991

Product	1991 Number of Sales	1991 Volume (Million lbs equivalent U_3O_8)	1990 Number of Sales	1990 Volume (Million lbs equivalent U_3O_8)
Concentrates	79	18.4	67	23.4
UF_6	20	7.7	37	9.7
EUP	13	3.9	14	7.0
TOTAL [1]	**112**	**30.0**	**118**	**40.1**

[1] Due to independent rounding, columns may not equal total.

in 1991 numerous suppliers continued to compete aggressively for sales even when market levels fell below $8.00 per pound. Supply was available from many sources, including utilities, producers, and government stockpiles. Uranium inventories from Australia, Africa, Canada, China, Germany, Italy, the former Soviet Union, eastern Europe, and the USA all had an impact on the market at some time during 1991.

NUEXCO's Transaction Value ranged from a high of $9.45 per pound U_3O_8 on February 28, 1991, to a low of $7.45 per pound on November 30. The volume-weighted average Transaction Value for 1991 was $8.51 per pound U_3O_8 based on an annual total of 90 transactions and 22.2 million pounds equivalent U_3O_8.

The Conversion Value edged up $0.10 during 1991, reflecting less aggressive competition among sellers. Although the shutdown of the Sequoyah Fuels conversion plant initially raised some concerns about supply availability, existing inventories, overcapacity worldwide, and relatively low demand limited the price increase.

The Loan Rate was unchanged for most of the year at 3.5 percent per annum. But by year end, the Loan Rate dropped to 3.0 percent due to abundant supply, decreased demand, and the general downturn of the interest rate structure in the USA. Loaned material continued to play an important role in the uranium market, as utilities, producers, and other market participants sought to utilize excess inventories. Loan volume in 1991 exceeded 13 million pounds equivalent U_3O_8, lagging the 1990 level of over 16 million pounds.

The SWU Value rose dramatically in 1991, starting the year at $51 per SWU, rising to $68 per SWU by October 31, and ending the year at $70 per SWU. Over 3.2 million SWU were traded in 1991 in 35 near-term transactions, compared to only 1.7 million SWU and 26 transactions in 1990. Contributing to the rise in the spot market were the marketing efforts by several primary enrichment suppliers, particularly offers by the US Department of Energy, Techsnabexport, and Louisiana Energy Services, leading many buyers into the market to examine SWU supply alternatives. Twenty-five long-term enrichment contracts were concluded during 1991, totalling 9.5 million SWU.

NATURAL URANIUM

Near-Term Market Activity

To most market participants' surprise, the NUEXCO Exchange Value fell, by October 31, 1991, to $7.25 per pound U_3O_8, an inflation-adjusted all-time low (**Figure 1**). While the market showed only moderate volatility during the year, other than an upturn in November and December in response to the record low-price levels and the filing of the anti-dumping petition in the USA, the Exchange Value declined steadily during most of the year. Many factors affected the market in 1991, yet the overriding influence was the same as it had been for the past few years: supply overwhelmed demand.

Annual uranium consumption in the Western World has outpaced actual production for much of the past decade, but producer, utility, and government inventories,

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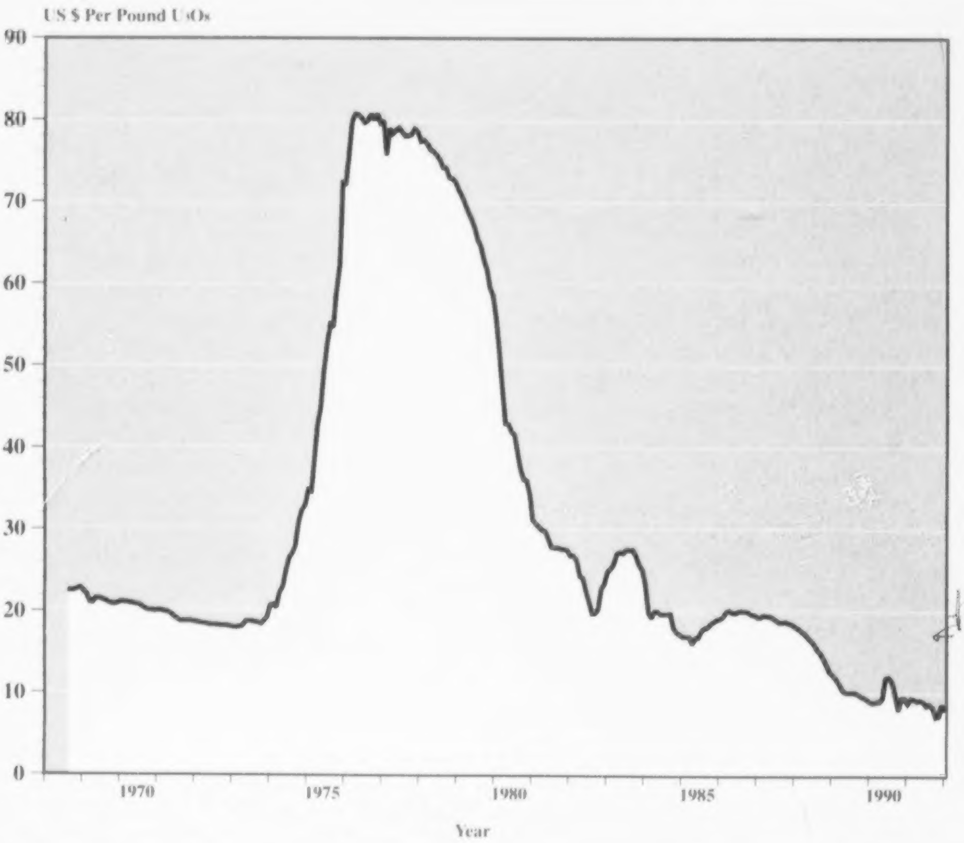
Figure 1
HISTORICAL INFLATION-ADJUSTED NUEXCO EXCHANGE VALUES
Constant 1991 Dollars



as well as production from other sources have more than filled the balance of demand. Although some forecasts annually predict that inventories will be drawn down soon, each year unanticipated supplies have appeared on the market. Initially, large utility and producer inventories in the USA and Europe met demand; then government stockpiles from countries such as Germany and Italy and exports from China became available; and more recently, uranium from the former Soviet Union and other east European countries have reached the market. With the end of the Cold War era, uranium from nuclear weapons stockpiles throughout the world may be the next major supply source. Excess supplies from multiple sources continue to drive the market, and until these various supplies are consumed or otherwise designated for particular uses, a significant and lasting price recovery appears doubtful.

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In addition to ample supply from numerous sellers and a decline in the level of demand, several other factors affected the uranium market in 1991.

Collapse of the Soviet Bloc—As the Commonwealth of Independent States (the former Soviet Union) and other east European countries move toward market-based economies, exports that earn hard currency, such as uranium, have taken on an important role in the economic transition. Natural uranium from the former Soviet Union has been marketed to the Western World since 1990 and enrichment services since the mid-1970s. Like other world suppliers, these countries have turned to the spot market to supplement their long-term marketing efforts.

Anti-dumping petition against the Soviet Union—On November 8, 1991, several uranium producers with US operations filed a petition with the US Department of Commerce and the US International Trade Commission charging that uranium was being dumped in the USA by the now former Soviet Union. This filing, and an influx of discretionary buyers attracted by October's record low prices, may have lead to a firming of the market in November and December. Market participants reacted differently to the filing, but many viewed the petition as just another complication in an already uncertain market.

Increasing number of spot market participants and the increasing role of traders—Spot market sales have acquired a larger and more important share of the total uranium market in recent years. More utilities, producers, and intermediaries than ever before are active in the spot market. This increased use of the spot market by many buyers and sellers has led to increased efficiency of the market, as utilities, producers, and intermediaries become more adept at balancing their short-term and long-term needs.

Reduced-Inventory Policies by Utilities—The decision by a number of utilities to reduce their inventory levels has significantly decreased demand. The new policies mandate that the utilities draw down their inventories to very low levels, consequently reducing demand. In some cases, particularly in the USA, utilities have adopted zero-inventory policies.

Further evidence of abundant supply—Recent uranium discoveries, such as that at McArthur River in Canada, reinforce the belief that uranium supply is plentiful and tends to alleviate concerns regarding long-term resource availability. In addition, disarmament of nuclear weapons throughout the world increases the perception that nuclear fuel supply will be plentiful.

Lifting of sanctions against South Africa—South Africa's progress toward ending apartheid led most countries to lift economic sanctions, although this action did not have a major effect on the uranium market in 1991. While South Africa's uranium production has dropped significantly in the past decade, the country still has large remaining reserves that are once again politically acceptable on the world market, albeit at production costs above current spot market levels. This availability further reinforces the perception of abundant long-term supply.

With most buyers purchasing concentrates in 1991, the UF_6 market was comparatively quiet. The relatively few UF_6 transactions that did occur during the year were greatly influenced by activity in the concentrates market, as buyers and sellers looked to the component markets of concentrates and conversion to get an indication of UF_6 market conditions. The UF_6 Value stayed in the mid-$27 range during the first half of the year, dropping to $25.50 per kg U as UF_6 at the end of the third quarter. The UF_6 Value then dropped to $22.75 per kgU on October 31, the all-time low for the UF_6 Value since it was first published on April 30, 1985.

Market Volume

Near-term uranium market volume during 1991 dropped to a total of 30.0 million pounds equivalent U_3O_8. This figure is significantly below 1990's record level of 40.1 million pounds, and also trails the 1989 level of 32.3 million pounds (**Figure 2**). Low prices in 1989 and 1990 brought significant discretionary demand into the spot market, and buyers, particularly utilities, pursued buy-and-hold strategies, which has effectively reduced their buying activity in the year following these large purchases.

The vast majority of 1991 sales involved natural uranium concentrates: 79 transactions totalled over 18.4 million pounds equivalent U_3O_8. Twenty natural UF_6 sales

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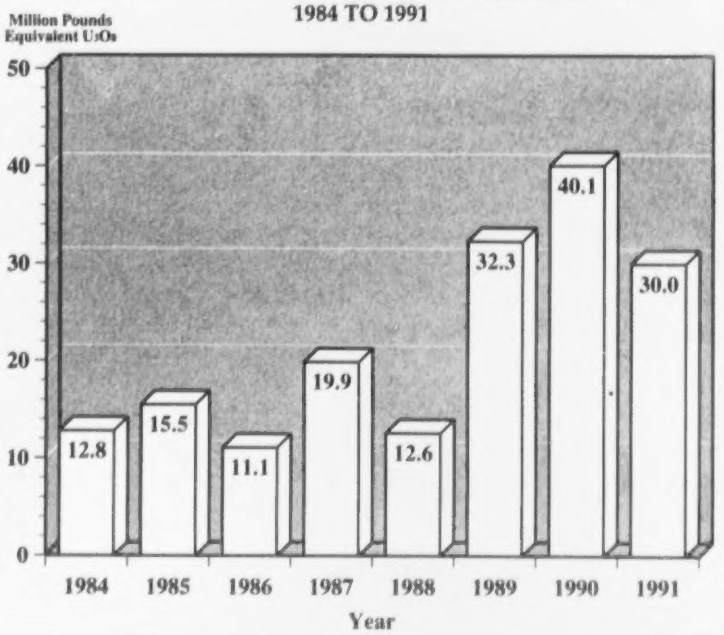
Figure 2
SPOT AND NEAR-TERM URANIUM SALES VOLUME
1984 TO 1991



accounted for 7.7 million pounds equivalent U_3O_8, and enriched uranium product (EUP) was involved in 13 sales for 3.9 million pounds. The 61-percent market share attributed to concentrates in 1991 exceeded the 1990 level of 58 percent (**Table 4**).

Table 4
FORM OF MATERIAL SOLD FOR SPOT AND NEAR-TERM DELIVERY
Percent Share of Volume (1985-1991)

	1985	1986	1987	1988	1989	1990	1991
Concentrates	67.1	42.2	57.0	62.3	74.8	58.3	**61.4**
Natural UF_6	31.6	51.0	35.5	27.4	15.9	24.2	**25.5**
EUP	1.3	6.8	7.5	10.3	9.3	17.5	**13.1**
Total	100.0	100.0	100.0	100.0	100.0	100.0	**100.0**

In general, market volume was equally distributed during the year, although volume increased during the fourth quarter, reflecting the record-low prices and the historical trend of increased activity at year-end (**Table 5**). Volume during the fourth quarter was skewed slightly higher by two major sales of concentrates and natural UF_6.

Transaction Value

The NUEXCO Transaction Value is a moving weighted average of prices paid for natural uranium in recent spot and near-term market sales (see *Market Values Definitions* in the Index section). During 1991, the Transaction Value reflected the slow, steady decline in market prices during the first half of the year. The Transaction Value began the year at $9.40 per pound U_3O_8 on January 31, peaked at $9.45 per pound on February 28, then declined to $9.15 on July 31. As the price decline accelerated (as represented by the Exchange Value), the Transaction Value dropped quickly through the $8.00 range during the next three months. The November 30, 1991, Transaction Value reflected the record low prices of October and November, and plummeted to $7.45 per pound U_3O_8, the lowest level ever in the 16-year history of the Transaction Value. Thereafter, it climbed to $7.50 at year end, and continued to ascend early in 1992. The higher range of the Transaction Value relative to the Exchange Value resulted from the usual lag of the Transaction Value behind the Exchange Value, and demonstrates the trend toward lighter volume associated with lower-priced discretionary transactions.

The 1991 weighted-average Transaction Value was $8.51 per pound U_3O_8, based on 90 transactions over 12 months involving 22.2 million pounds equivalent

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Table 5
QUARTERLY NEAR-TERM URANIUM SALES VOLUME – 1991

Quarter	Number of Sales	Volume (million pounds equivalent U_3O_8)	Percent Share of Total Volume
First	31	6.5	21.6%
Second	27	7.2	24.2%
Third	26	6.7	22.3%
Fourth	28	9.6	31.9%
Total	**112**	**30.0**	**100.0%**

U_3O_8. The annual weighted average differs from a simple average of the twelve monthly Transaction Values. The annual average includes only 1991 transactions; it excludes any 1990 transactions used in the Transaction Value calculation for early 1991. The sum of the quantities sold in the qualifying 1991 transactions is divided into the total of the product-times-quantity calculations, to yield the weighted average 1991 Transaction Value.

Uranium Supply and Demand

Reported active uranium supply averaged 6.2 million pounds equivalent U_3O_8 per month during 1991 (**Table 6**). This represents a 35-percent increase compared to the 1990 monthly average of almost 4.6 million pounds. In contrast, active uranium demand in 1991 equalled 1.7 million pounds equivalent U_3O_8 per month, a 31-percent decrease from the 1990 average of 2.5 million pounds. These figures exemplify the typical supply/demand imbalance in the 1991 spot market that led to the year's record-low price levels.

Oversupply continues to characterize the market. Utility, producer, and government stockpiles still have a large influence on the market either by their availability for sale or loan, or because the existence of such stockpiles defers purchasing activity. Compared to past years, the supply situation in 1991 was unique in that numerous suppliers competed aggressively at low price levels throughout the year. Previously, as prices reached a certain threshold, such as $9.00 per pound or $8.00 per pound,

Table 6
1991 ACTIVE URANIUM SUPPLY AND DEMAND

Determined as of the Last Day of the Month	Published in Report Number	Supply	Demand	Supply/ Demand Ratio
		(thousand pounds equivalent U_3O_8)		
January	270	5,200	1,600	3.2
February	271	5,375	2,485	2.2
March	272	5,300	3,875	1.4
April	273	6,085	1,455	4.2
May	274	7,130	1,400	5.1
June	275	11,180	1,695	6.6
July	276	6,030	850	7.1
August	277	6,630	1,213	5.5
September	278	5,115	450	11.4
October	279	7,315	1,610	4.5
November	280	5,030	2,925	1.7
December	281	4,000	860	4.7
Annual Averages [1]		**6,200**	**1,700**	

[1] Simple arithmetic averages.

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most suppliers would withdraw from the market. In 1991, even when prices approached $7.00 per pound, several suppliers were still competing for sales.

Much of the year's demand came from discretionary buyers. With the record volume of purchases in 1990, these buyers were tempted to enter the market only when prices reached historically low levels. As demand increased in response to such low prices, and supply tightened, prices rose. But, market participants reacted more cautiously than in previous years, and by early January 1992, the price had again stabilized around the $8.00 per pound level.

TRANSACTION ANALYSIS

Spot and Near-Term Sales

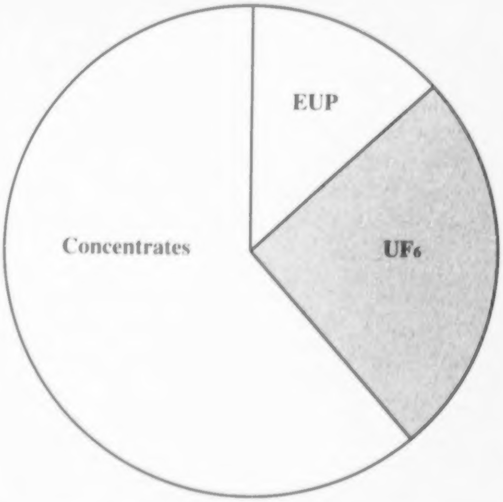
Slightly more than 30 million pounds equivalent U_3O_8 in the form of concentrates, natural UF_6, and EUP were traded in 112 transactions in the 1991 near-term uranium market. This volume represents a 25-percent decrease from the 1990 record of 40.1 million pounds. However, the number of transactions decreased by only five percent (112 vs. 118) indicating a 21-percent drop in the average transaction size. These figures include all 1991 near-term uranium transactions reported in Monthly Reports #270-281, 11 transactions that occurred in 1991 but were not reported previously, as well as one transaction that occurred in 1991 but had been reported in 1992 due to delays in receiving accurate information. NUEXCO's reporting of nuclear fuel transactions is subject to some limitations.

Transactions that may not have been reported include the following:

- Transactions (or certain information about published transactions) which, if reported, would jeopardize client confidentiality.
- Transactions for which insufficient reliable information is available.
- New deliveries, or the exercise of options for additional material, under old contracts.
- Transactions involving material other than concentrates, natural UF_6, or enriched uranium product.
- Transactions involving back-to-back sales; normally only one transaction is reported. However, when complex trading activities are involved, two separate transactions may be reported, if warranted.
- Transactions involving only exchanges of origin, location, form, or other commercially significant attributes.

Natural uranium concentrates accounted for about 61 percent of the uranium sold in 1991 (**Figure 3**). Natural UF_6 made up about one quarter of the total, and EUP sales contributed 13 percent of the year's volume. **Table 7** shows this data by buyer and seller type.

Figure 3
1991 NEAR-TERM URANIUM SALES VOLUME SHARE BY PRODUCT



Buyers

Utilities were the most active buyers in 1991, purchasing over 46 percent of the year's total near-term volume, an increase over their 1990 share of 40 percent. Notably, producers became the second-largest group of buyers in 1991, purchasing nearly eight million pounds (26 percent) in 31 transactions and surpassing intermediaries who were the second-largest group of buyers in 1990. Most spot market purchases by producers were used to fill long-term contract commitments. Intermediaries accounted for 17 percent of total purchase volume in 23 transactions. Five purchases by converters, enrichers, fabricators, and unidentified buyers combined to account for the remaining 11 percent of total volume.

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Table 7
ANALYSIS OF 1991 SPOT AND NEAR-TERM URANIUM SALES

	Concentrates		UF_6		Enriched Uranium Product		Total[1]	
SALES BY	**Number of Sales**	**Million Lbs. Equivalent U_3O_8**	**Number of Sales**	**Million Lbs. Equivalent U_3O_8**	**Number of Sales**	**Million Lbs. Equivalent U_3O_8**	**Number of Sales**	**Million Lbs. Equivalent U_3O_8**
PRODUCERS to:								
Utilities	5	1.0	—	—	—	—	**5**	**1.0**
Producers	4	0.7	—	—	—	—	**4**	**0.7**
Intermediaries	5	1.3	—	—	—	—	**5**	**1.3**
Others	—	—	—	—	—	—	**—**	**—**
Total	**14**	**3.0**	**—**	**—**	**—**	**—**	**14**	**3.0**
UTILITIES to:								
Utilities	—	—	—	—	1	0.6	**1**	**0.6**
Producers	—	—	—	—	—	—	**—**	**—**
Intermediaries	1	<0.1	—	—	—	—	**1**	**<0.1**
Others	—	—	1	2.6	—	—	**1**	**2.6**
Total	**1**	**<0.1**	**1**	**2.6**	**1**	**0.6**	**3**	**3.3**
INTERMEDIARIES to:								
Utilities	25	5.2	10	3.7	7	2.6	**42**	**11.5**
Producers	24	6.8	—	—	—	—	**24**	**6.8**
Intermediaries	6	1.8	6	0.8	2	0.3	**14**	**2.9**
Others	2	0.3	—	—	1	<0.1	**3**	**0.4**
Total	**57**	**14.2**	**16**	**4.6**	**10**	**3.0**	**83**	**21.7**
OTHER ENTITIES to:								
Utilities	2	0.2	2	0.3	1	0.1	**5**	**0.6**
Producers	3	0.4	—	—	—	—	**3**	**0.4**
Intermediaries	2	0.6	—	—	1	0.3	**3**	**0.9**
Others	—	—	1	0.1	—	—	**1**	**0.1**
Total	**7**	**1.2**	**3**	**0.5**	**2**	**0.4**	**12**	**2.0**
TOTAL	**79**	**18.4**	**20**	**7.7**	**13**	**3.9**	**112**	**30.0**

[1] Due to independent rounding, column and row sums may not equal totals.

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Market activity in 1991 was concentrated in the USA: US entities made 77 purchases for 15.7 million pounds equivalent U_3O_8, or approximately 52 percent of total market volume. European buyers accounted for about 26 percent of the volume in 18 purchases. Australian and Canadian buyers purchased nearly five million pounds in ten purchases, for 17 percent of total volume. Asian, African, and unidentified buyers make up the balance (**Figure 4**). The high level of spot market activity in the USA is not unusual, given that US utilities typically have allocated a greater portion of their contract portfolio to near-term contracts than their counterparts in Europe or Asia, and therefore have greater uncommitted requirements.

Sellers

Unlike previous years, when low prices caused many suppliers to leave the market, in 1991 numerous suppliers continued to compete aggressively, even when prices were near record-low levels. Price pessimism and a general sense among suppliers that real demand would remain light during 1991, led sellers to stay in the market.

Intermediaries were the primary sellers in the 1991 near-term uranium market, selling almost 22 million pounds equivalent U_3O_8 in 83 sales and accounting for 72 percent of market volume. Producers and utilities each sold roughly ten percent of the total volume. Twelve sales by a combination of converters, enrichers, fabricators, and unidentified sellers accounted for the remaining seven percent.

Intermediaries' role as the major sellers in the market has evolved in part because of the availability of large inventories held by utilities or governments, who often turn to intermediaries for assistance in marketing their stockpiled material. The predominance of intermediaries as sellers also can be attributed to the presence of producers as buyers in today's market. With spot prices lower than some production costs, producers may buy, rather than producing the material themselves, to fill long-term contract commitments.

Most near-term market activity in 1991 involved US entities as sellers. Approximately 64 percent of the year's total sales volume could be attributed to US-based sellers (**Figure 5**). European sellers accounted for 28 percent of the volume in 21 sales. Canadian and Asian sellers each accounted for only two percent of the total. African and unidentified entities made up the balance.

Figure 4
1991 NEAR-TERM BUYERS BY TYPE AND ORIGIN
(Percent share by volume)

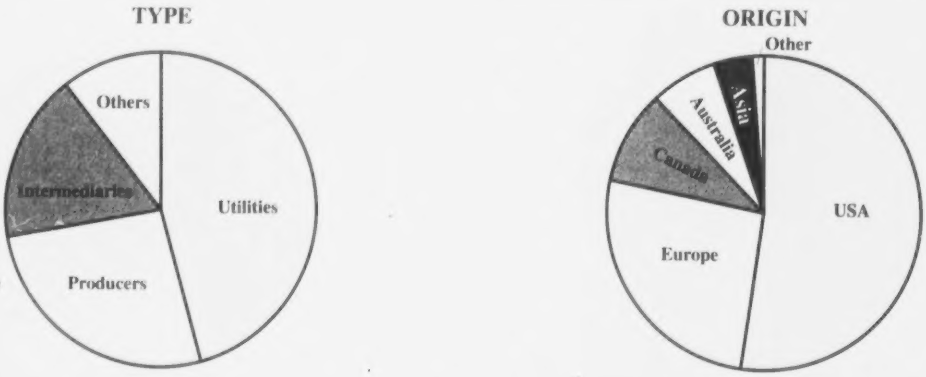
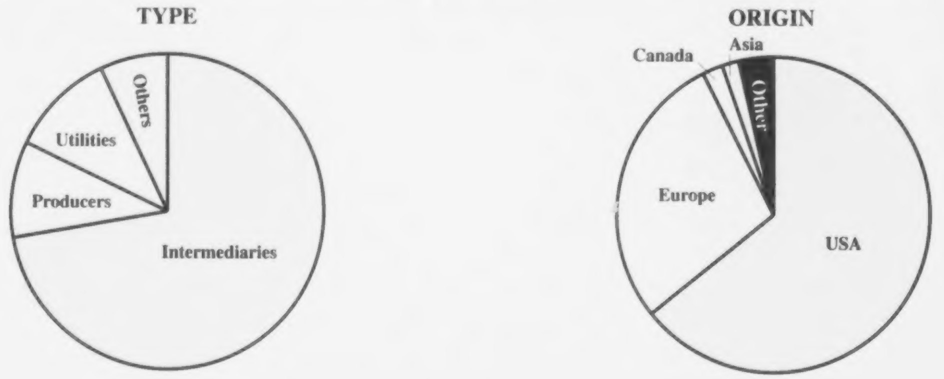


Figure 5
1991 NEAR-TERM SELLERS
BY TYPE AND ORIGIN
(Percent share by volume)



LONG-TERM MARKET ACTIVITY

The long-term uranium market was very active in 1991, nearly equalling 1990's volume of 54 million pounds, and surpassing the 37 transactions of 1990. Fifty new long-term contracts, totalling 53.8 million pounds equivalent U_3O_8, were reported in 1991. Contracted delivery dates ranged from 1991 through 2001; 41 transactions involved concentrates, seven involved natural UF_6, and two involved EUP. Sales by producers accounted for 60 percent of the volume and intermediaries for 27 percent; two sales, representing the remaining 13 percent, were by undisclosed sellers.

Unlike 1990, when the majority of new long-term contracts employed market-related pricing, sales in 1991 were more equally divided among the three primary types of pricing. Base-escalated pricing regained its position as the favored contract pricing formula, being utilized in at least nineteen new contracts involving nearly 25 million pounds equivalent U_3O_8 (**Figure 6**). Market-related pricing was used in 16 contracts, and fourteen contracts used a series of fixed prices. The terms of one of the reported contracts is undetermined.

As expected, utilities were the dominant buyers, purchasing over 50 million pounds equivalent U_3O_8 in 46 transactions. Two intermediaries and two producers made comparatively small purchases to account for the remaining sales.

Most sales were made to US utilities, accounting for about 45 percent of the long-term sales volume. Ten purchases by European entities totalled 28 percent of the year's volume. Asian utilities made 15 long-term purchases to account for the remaining 27 percent. In general, contracts employing base or fixed prices reflected the continuing downward movement of the spot market. In recent years, most long-term supply contracts signed in the USA have involved market-related pricing, and while this trend is not as prevalent in Europe and Asia, utilities in those regions exhibited an increasing interest in market-related pricing as a result of spot-market declines. For producers, this could be a disconcerting trend, particularly in Asia, where security of supply has long been considered the most important issue in fuel contracting.

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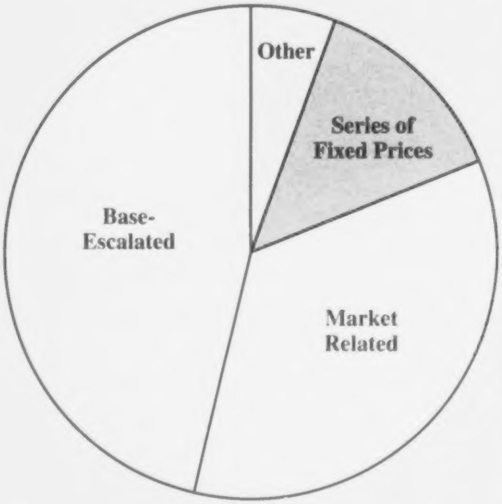
Figure 6
1991 LONG-TERM URANIUM CONTRACTS
VOLUME SHARE BY PRICING TERMS



URANIUM LOANS

The Loan Rate was unchanged at 3.5 percent per annum for most of the year, having remained at that level since November 1987. However, by year-end, the abundance of loan supply, limited demand, and falling interest rates in the USA all combined to push the Loan Rate down to 3.0 percent per annum on December 31, 1991. Loans continued to play an important role in the uranium market, by filling spot demand and deferring purchases to a later date, and by allowing holders of excess inventories to realize a return on that material. The availability of these inventories added to the market's oversupply situation and contributed to the price weakness exhibited by the near-term uranium market.

Nineteen natural uranium loans were reported in 1991: 16 were concentrates loans involving 11.9 million pounds U_3O_8; three were natural UF_6 loans involving 1.5 million pounds equivalent U_3O_8. Despite the downward pressure on the Loan Rate during the year, the large majority of the loans concluded during 1991 took place near 3.5 percent. Intermediaries were the primary borrowers, receiving more than half of the year's total volume in 14 loans. Producers borrowed some 20 percent of the total, with utilities borrowing the balance.

Lenders were quite diverse, and included utilities, producers, intermediaries, fabricators, and converters. Most of the lenders were from the USA with ten loans for 8.8 million pounds equivalent U_3O_8, and Europe with eight loans for 4 million pounds.

In addition to the natural uranium loans reported, NUEXCO is aware of at least eight EUP loans involving almost 1.4 million pounds equivalent U_3O_8 and 360 thousand SWU.

CONVERSION SERVICES

The Conversion Value, which had remained at $1.45 per pound U as UF_6 for 14 consecutive months, moved up modestly to $1.50 per pound U on May 31, 1991. The Conversion Value then settled at $1.55 per pound U on September 30, and remained at that level through the end of the year (**Table 8**). This slight increase reflected the gradual reduction, during the second and third quarter of 1991, of the UF_6 supplies that were overhanging the market early in the year. It also reflected reduced competition among sellers.

Only nine near-term conversion sales were reported during 1991, totalling less than 2 million pounds U as UF_6. This figure is significantly less than the previous year's twenty sales for almost 7 million pounds. In 1991, while comparatively higher volumes of concentrates changed hands in the spot market, much of the spot material was converted to UF_6 under existing long-term contracts; thus, fewer spot conversion needs existed. In nine near-term conversion transactions in 1991, seven utilities and two intermediaries purchased conversion services from converters (4 sales) and intermediaries (5 sales). Seven of the sellers were US entities, while buyers were two-thirds US and one-third European. By volume, utilities accounted for 87 percent of the purchases, and converters, for 60 percent of the sales. US-based companies bought 78 percent of the material and sold 88 percent of total sales volume.

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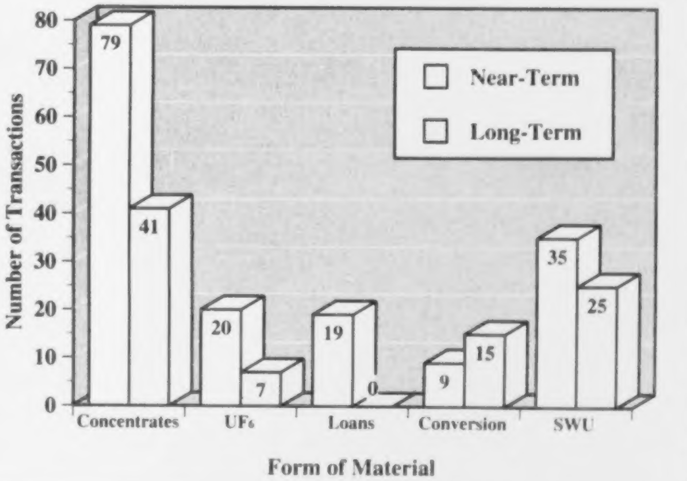
Figure 7
1991 TRANSACTIONS
BY FORM AND TERM



The long-term conversion market was very active in 1991, as 15 sales were reported, totalling more than 33 million pounds U as UF6 for delivery during the period 1991-2001. Although the sales volume was very large, the average was skewed due to one large sale to a utility. Nevertheless, the long-term conversion market was more active than in any of the past few years. Twelve utilities and three intermediaries made long-term conversion purchases in 1991, with utilities accounting for 91 percent of the volume. In all but one instance, sellers were primary converters. The other was an inventory sale by a utility. Ten of the buyers were US-based entities; the others were Asian (4 purchases) and European (one purchase).

Table 8
1991 NUEXCO CONVERSION VALUE

Determined as of the Last Day of the Month	Report Number	Conversion Value Per Pound U as UF6	Conversion Value Per Kg U as UF6
January	270	$1.45	$3.20
February	271	$1.45	$3.20
March	272	$1.45	$3.20
April	273	$1.45	$3.20
May	274	$1.50	$3.31
June	275	$1.50	$3.31
July	276	$1.50	$3.31
August	277	$1.60	$3.53
September	278	$1.55	$3.42
October	279	$1.55	$3.42
November	280	$1.55	$3.42
December	281	$1.55	$3.42
1991 Averages[1]		**$1.51**	**$3.33**

[1] Simple arithmetic averages.

ENRICHMENT SERVICES

After remaining near the $50-per-SWU level for most of 1990, and beginning 1991 at $51 per SWU, the SWU Value edged upward during the first and second quarters, and moved to $59 per SWU on June 30 before jumping to $66 on July 31. It then slowed its rate of increase, and remained at $68 during October and November. In December, the SWU Value resumed its rise, moving up to $70 per SWU at year end (**Table 9**). The increase was due primarily to the clearing of several blocks of EUP inventory from the market, including the German and Italian government stockpiles. The other major factor in the price rise was the rapid increase in SWU demand, particularly during the second and third quarters of the year.

A total of 3.2 million SWU were sold in 35 SWU and enriched uranium product transactions, compared to 1.7 million SWU in 26 transactions in 1990. Of the 1991 transactions, 22 were SWU-only sales (those sales in which the uranium feed

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Table 9
1991 NUEXCO SWU VALUE

Determined as of the Last Day of the Month	Report Number	US$ per SWU
January	270	$51.00
February	271	$50.00
March	272	$52.00
April	273	$52.00
May	274	$54.00
June	275	$59.00
July	276	$66.00
August	277	$67.00
September	278	$67.00
October	279	$68.00
November	280	$68.00
December	281	$70.00
1991 Average [1]		$60.33

[1] Simple arithmetic average.

component was not sold) totalling 2.3 million SWU. The thirteen other sales involved almost 900 thousand SWU contained in EUP. By far the largest volume of sales occurred during the middle of the year, as 75 percent of all SWU sold in the 1991 near-term enrichment market changed hands during the second and third quarter. Ten of the year's transactions were for quantities greater than 100 thousand SWU. The number of EUP transactions in 1991 was the same as in 1990, but the 1991 transactions contained about 12 percent fewer SWU in total.

As expected, utilities were the predominant buyers during the year, purchasing 73 percent of the total near-term SWU volume. Intermediaries were the primary sellers, accounting for 68 percent of the sales. Utilities sold 28 percent of the total volume, with fabricators and enrichers making up the balance. Market activity was split between the USA and Europe: US buyers purchased 55 percent of the total SWU volume, while European entities sold about two-thirds of the material.

In the long-term SWU market, 1991 witnessed the highest level of long-term enrichment contracting activity since the introduction of DOE's Utility Services Contract in the mid-1980s. Many utilities, especially in the USA, began the year uncommitted for SWU supplies beyond 1995. Aggressive marketing efforts by several suppliers caused many utilities to enter the market to evaluate supply alternatives. Many options existed, including DOE's "Enhanced IP-3" and SWU-for-power offers; future production from Louisiana Energy Services or from CRISLA Technologies; long-term contracting with GNSS; and buy-and-hold strategies utilizing the spot SWU market. At least 42 utilities evaluated offers for near- and long-term supplies during 1991; in addition, at least 12 other buyers (fabricators, enrichers, intermediaries, etc.) also evaluated SWU offers during the year.

While not all buyers elected to make purchases, a review of 1991 long-term enrichment transactions indicates that utilities contracted for almost 9.5 million SWU in 25 agreements, compared to only 9 contracts in 1990. Twenty-three of the transactions involved SWU-only sales and two involved SWU contained in EUP. Delivery periods ranged from 1991 through 2002.

Buyers were all utilities, with most from the USA (22); European (2) and Asian (1) utilities made up the balance. By volume, primary enrichers accounted for 95 percent of the sales. Three sales by intermediaries made up the balance of five percent. The US Department of Energy's "Incentive Price-3" contracts were the most prevalent transactions. The pricing terms on the balance of the contracts were split almost equally between base-escalated and fixed-price terms.

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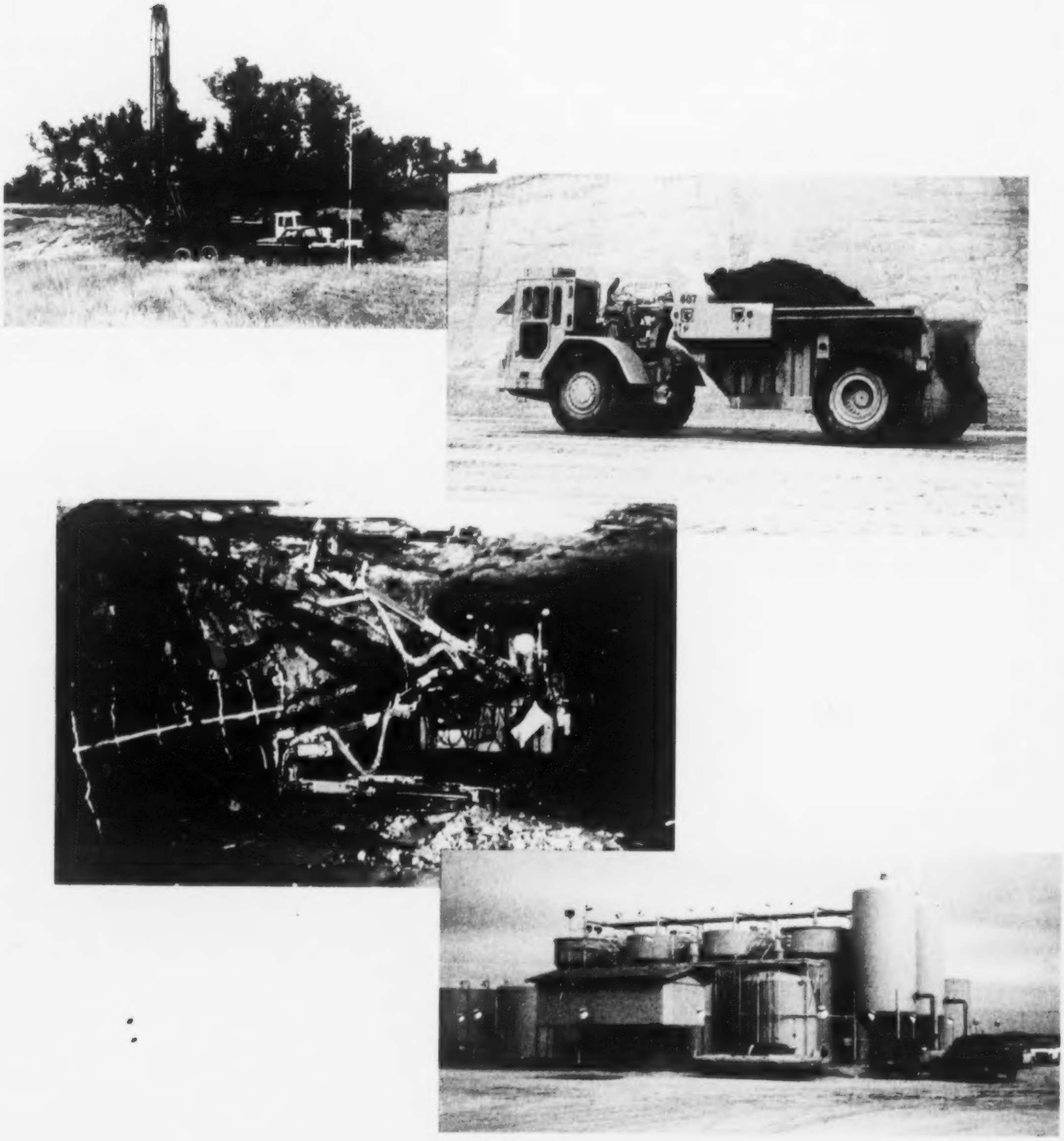
URANIUM DEVELOPMENTS



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WORLD URANIUM PRODUCTION

Western World uranium production continued its decline in 1991, dropping eleven percent, to 65.5 million pounds U_3O_8. All the major uranium producing countries, with the exception of Australia, experienced significant production decreases, ranging from 6 to 33 percent (**Table 10**). Uranium exports from eastern Europe and China to the Western market continued to grow, reaching approximately 20 million pounds equivalent U_3O_8 in 1991.

CANADA

Canada has been the world's largest uranium producer since 1984, the year it first succeeded the USA in that position. During 1991, Canada produced 21.3 million pounds U_3O_8, down 6.7 percent from 1990. Production continued to shift away from the eastern Canadian province of Ontario, with 1991 production in Ontario at 3.5 million pounds U_3O_8, less than half that of 1990. During 1991, contract renegotiations with Ontario Hydro resulted in the termination of Denison's primary supply contract. As a result, Denison plans to close its Elliot Lake operation by mid-1992, when contracted deliveries are scheduled to end. Rio Algom's Stanleigh mine will then be the only active uranium operation in Ontario. The 1991 production decreases in Ontario were partially offset by increases in Saskatchewan. In mid-1991, Cameco restarted the Rabbit Lake mill. Cameco also reported a nearly ten-percent increase in production at Key Lake, the largest uranium production center in the Western World. Saskatchewan's total production in 1991 was 17.8 million pounds U_3O_8.

AUSTRALIA

Australian production increased 7.4 percent, to 9.8 million pounds U_3O_8 in 1991. Although output from Energy Resources of Australia's Ranger operation was up during the year, ERA announced a staff reduction of over 40 percent, and production cutbacks to levels more in line with expected future sales. Production at Olympic Dam, the joint venture of Western Mining Corporation and British Petroleum, also was higher during 1991. Furthermore, the joint venture partners announced their decision to proceed with an expansion program scheduled for completion by mid-1992. This expansion focuses primarily on copper production, which will be increased by nearly 50 percent, while uranium production capacity will be increased by 15 percent.

The Australian "three-mine policy" continues to limit uranium production to three approved producers: ERA at Ranger; the Western Mining - BP joint venture at Olympic Dam; and Queensland Mines at Nabarlek, which ceased operating in 1988. This policy recently came under review at the Labor Party's Biennial Conference in June 1991. Although the Party was sharply divided over the issue, the Uranium Policy Review Committee recommended elimination of the three-mine policy. However, the Party ignored this recommendation and decided to maintain the restrictive policy, which will now remain in force for an unspecified period of time.

USA

Uranium production in the USA continued to decrease, dropping eleven percent, to 7.9 million pounds U_3O_8 in 1991. Much of this decrease is attributable to the shutdown of Umetco's White Mesa mill at Blanding, Utah, which had been processing ore from Umetco's mining operations in the Colorado Plateau, as well as ore from Energy Fuels' Arizona Strip mining operation. Although milling ceased in late 1990, Energy Fuels continued to mine and stockpile ore into the first quarter of 1991. Other closures announced during 1991, included mining operations at Pathfinder's Shirley Basin project in Wyoming, and the Rhode Ranch project in Texas, now controlled by General Atomics, which acquired Chevron's 55-percent interest in the project during 1991 (**Figure 8**). Milling operations associated with the Shirley Basin and Rhode Ranch projects will continue into the first quarter of 1992, although these closures have brought conventional mining in the USA to a standstill. During 1991, conventional and mine-water production totalled 2.5 million pounds U_3O_8, accounting for only 32 percent of US production, compared to 43 percent in 1990.

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Table 10
URANIUM PRODUCTION AND EXPORTS – 1987-1991 [1]

	Production and Exports (Million Pounds Equivalent U_3O_8)					1991 Relative to 1990	Market Share [2]	
	1987	1988	1989	1990	1991		1987	1991
PRODUCTION:								
Australia	9.8	9.3	9.5	9.1	9.8	+ 7.7%	10.3%	11.4%
Canada	32.3	32.4	29.4	22.8	21.3	– 6.6%	34.0%	24.7%
France	8.7	9.0	8.4	7.4	6.6	– 10.8%	9.1%	7.7%
Gabon	2.1	2.4	2.3	1.8	1.6	– 11.1%	2.2%	1.9%
Namibia	9.2	9.1	8.0	8.3	6.4	– 22.9%	9.7%	7.4%
Niger	7.3	7.7	7.7	7.4	5.9	– 20.3%	7.7%	6.9%
South Africa	10.3	9.9	7.7	6.4	4.3	– 32.8%	10.8%	5.0%
USA	12.4	13.4	13.8	8.9	7.9	– 11.2%	13.0%	9.2%
Other [3]	2.4	2.4	2.5	1.7	1.7	0.0%	2.5%	2.0%
EXPORTS:								
Eastern Europe [4] & China	0.6	1.3	3.6	10.7	20.6	+ 92.5%	0.6%	23.9%
Total	**95.1**	**96.9**	**92.9**	**84.5**	**86.1**	**1.9%**	**100%**	**100%**

[1] Figures presented are NUEXCO's best estimates.

[2] Expressed as a percentage of total production.

[3] Includes Argentina, Belgium, Brazil, India, Pakistan, Portugal, Spain, western Germany, and Slovenia.

[4] Includes only that portion of production and inventory exported to Western countries.

Phosphate by-product production surpassed conventional production, accounting for nearly 40 percent of US production during 1991. IMC Fertilizer was the year's leading producer, with a total of 2.1 million pounds U_3O_8 as a by-product of phosphoric acid operations in Florida. Another plant producing uranium as a by-product of phosphoric acid, Freeport's Donaldsonville plant in Louisiana, restarted operations during 1991.

In-situ leaching's share of US production also increased dramatically from 13 percent to 28 percent. Of the four production centers that came on-line during 1991, three were ISL projects, including Ferret's Crow Butte project in Nebraska, and Total Minerals' El Mesquite and Christensen Ranch projects, located in Texas and Wyoming, respectively.

FRANCE

The decline in French uranium production continued, with 1991 production down 10.8 percent from the previous year, to 6.6 million pounds U_3O_8. This decrease resulted from the closure of Cogema's Chardon and La Commanderie mines, and the associated mill at Ecarpière in western France. These facilities were the last in the division to remain open after Cogema began closing its Vendée Division in 1990.

NAMIBIA

Output from the Rössing Mine, Namibia's sole uranium operation, dropped nearly 24 percent, to 6.4 million pounds U_3O_8 in 1991. Twice during the year, the company reduced the mine's production rate in order to bring output more in line with current sales commitments. The project is now operating at approximately 50 percent of its rated capacity.

NIGER

Uranium production in Niger dropped significantly, to 5.9 million pounds U_3O_8 during 1991. This decrease accompanies the 20-percent staff reductions effected at both the Akouta and Arlit mines during the previous year.

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Figure 8 — Rhode Ranch Open-Pit Uranium Mine. GA's project was closed at the end of 1991 for full reclamation. *(Photo courtesy of GA)*

SOUTH AFRICA

The removal of most anti-apartheid sanctions against South Africa during 1991 had minimal effect on sales, and the country's uranium production dropped nearly twice as much as in the previous year, to only 4.3 million pounds U_3O_8. During 1991, two additional uranium facilities were closed: Gencor's Buffelsfontein plant and Anglo American's ERGO plant. These closures, combined with last year's reductions at Vaal Reefs and the closure of Anglo American's Joint Metallurgical Scheme, led to the country's production decrease in 1991. The current output level of 4.3 million pounds is far below South Africa's annual output of 10 to 15 million pounds U_3O_8 in the 1980s when the country was one of the world's top three producers.

GABON

Uranium production at Gabon's Oklo/Mounana project decreased by approximately 14 percent, to 1.6 million pounds U_3O_8 in 1991. These cutbacks were effected in order to increase productivity. The Boyindzi mine was closed during the year, and staff elsewhere was cut by seven percent.

EASTERN EUROPE AND CHINA

Uranium exports to the Western market from China and eastern Europe—including the former Soviet Union, eastern Germany, the Czech and Slovak Federal Republic, Hungary, Bulgaria, and Romania—totalled approximately 20 million pounds equivalent U_3O_8 in 1991. The majority of these exports came from the former Soviet Union. Their volume rose to this level from zero during 1985, with relatively insignificant volumes appearing before 1990. The recent rapid increase in Soviet uranium export volumes led the Ad Hoc Committee of Domestic Uranium Producers and the Oil, Chemical and Atomic Workers Union to file an anti-dumping petition with the US International Trade Commission and the US Department of Commerce.

OTHER

Production from the smaller uranium producing countries remained relatively stable in 1991, totalling approximately 1.6 million pounds U_3O_8. On a country-by-country basis, however, production levels moved in every direction: some increased, some decreased, and some remained stable. The countries exhibiting stable production levels were India, Belgium, and Spain. Production in Spain, however, is expected to increase dramatically in the near future, when the expansion currently underway at Saelices el Chico is complete. Argentina, Brazil, and Pakistan recorded production increases in 1991, but still only totalled about 200 thousand pounds U_3O_8. Conventional production ceased during 1991 in Portugal, and Slovenia, which recently declared independence from Yugoslavia. In Portugal, the open-pit mines at Urgeirica, which until recently provided approximately 75 percent of total production, were closed. All production is now derived from mine water recovery methods. The Zirovski Vrh mine in Slovenia stopped production in 1990 and made its last shipment of yellowcake in early 1991.

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EXPLORATION & DEVELOPMENT

Large inventories and depressed market prices continue to dampen any significant exploration and development in the world's uranium industry. Minimal activity occurred in 1991, and numerous consolidations within the uranium industry highlighted the year.

North America remained the largest uranium producing and exporting area of the world in 1991, and despite the record-low spot market prices, some exploration and definition drilling, as well as some assessment drilling, continued.

NORTH AMERICA

Canada

Uranium exploration drilling in Canada dropped considerably in 1991, falling to an estimated 738 thousand feet, of which 538 thousand feet was exploratory drilling and 200 thousand feet was development/production drilling. The peak drilling period was the month of March 1991, with 19 rigs operating—nine on exploration, three on development, and seven underground.

Five operations comprised uranium production in Canada in 1991. Two were underground mines at Elliot Lake with Rio Algom and Denison Mines; the others were open-pit operations at Cluff Lake, Key Lake, and Rabbit Lake in Saskatchewan's Athabasca Basin. Cameco restarted the Rabbit Lake mill in August after a two-year shutdown to modify the solvent extraction circuits. The mill feed was provided by the stockpile of ore from the Collins Bay B-Zone (**Figure 9**).

Also during 1991, Cameco announced a 60 million-pound increase in probable reserves at the McArthur River deposit in Saskatchewan. The deposit is now estimated to contain 260 million pounds U_3O_8 in reserves at an average grade of 5.0 w/o U_3O_8. Ore from this deposit probably will be processed at the Key Lake mill following depletion of the Key Lake deposits in the latter part of the decade.

In April, the federal government and the Saskatchewan government announced the formation of a joint federal-provincial review panel for proposed uranium developments. The panel will review the environmental health, safety, and socio-economic impacts of individual proposed developments, as well as the cumulative impact of all proposed uranium projects in Saskatchewan. The panel has only recently begun to review proposals, so its impact on uranium project development is unknown.

Figure 9 — Cameco's Collins Bay Uranium Deposit. Stockpiled ore from this deposit is fed to the restarted Rabbit Lake Mill. *(Photo courtesy of Cameco)*

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Another significant event that may affect the Canadian uranium industry was the victory of the socialist New Democratic Party (NDP) in Saskatchewan's provincial elections on October 21, 1991. The NDP maintains a strong anti-nuclear platform and called for a moratorium on uranium production in Saskatchewan. Ironically, the NDP was last in power in Saskatchewan in the early 1980s and was instrumental in developing uranium mining in the province. While the Party now opposes nuclear power and uranium mining, its call for a moratorium is hedged by the provision that other employment must be found for the province's uranium miners before the moratorium is implemented.

In a long-awaited step, Cameco began its privatization process in June, with an initial public offering of 10.4 million shares of common stock. Additional offerings later in the year boosted public ownership to 42 percent of the company as of January 30, 1992. The rest of the company is owned by the province of Saskatchewan (39 percent) and the Canadian government (19 percent).

In late May, Rio Algom, Ltd. (RAL) and Uranium Resources, Inc. (URI) agreed to a merger in which Rio Algom Mining Corporation (which is owned by RAL) would acquire all outstanding URI shares. Rio Algom already owned eight percent of URI. However, during third quarter 1991, the merger met an unexpected snag that postponed the deal. Both firms still supported the merger, but a Canadian tax issue arose that made the deal prohibitively expensive for Rio Algom. While there was hope to resolve this issue, on November 27 Rio Algom ended the merger agreement, citing the depressed uranium market. No comment was made regarding the effects of the tax law on the cancellation of the merger.

United States

US uranium operations for 1991 involved 23 firms performing exploration and development drilling to maintain claim holdings in Wyoming, Texas, Nebraska, Arizona, and Colorado. Exploratory drilling totalled about 615 thousand feet for the year, and development and production drilling amounted to almost 950 thousand feet. Most of the development and production drilling involved *in-situ* leaching (ISL) projects. As usual, the peak drilling month was August, with 46 rigs in operation as companies rushed to complete assessment requirements prior to September 1, the deadline for meeting minimum assessments to maintain holdings.

Two open-pit mines were active in the USA during 1991. The Rhode Ranch mine in Texas was operated by Chevron until August 1, when the sale to General Atomics was officially completed. GA's subsidiary, Rio Grande Resources, continued production through the end of the year. As of December 31, 1991, the Rhode Ranch mine was closed to begin full reclamation. Pathfinder Mines also operated the Shirley Basin open-pit mine during 1991, but has announced plans to phase out open-pit mining at this Wyoming deposit during the first half of 1992.

Arizona Strip

Energy Fuels Nuclear (EF) and Pathfinder Mines were the only producers conducting work in the Arizona Strip. EF discontinued mining at its Kanab North site in mid March, and began a 14-week drilling program on the north edge of the canyon in May. Pathfinder's activity in the strip involved one exploratory drilling rig north of the canyon.

Nebraska

Ferret Exploration of Nebraska (FEN) operated several development rigs at its Crow Butte site (**Figure 10**). Production began last spring and progressed according to plan; the company spent much of the year refining and improving its wellfield balance. Ferret Exploration (the parent company of FEN) also conducted some further exploratory drilling at some of its sites in Nebraska and Colorado. Later in the year, it became known that the 60-percent equity interest in the Crow Butte project held by Geomex, Inc. and its partners was for sale.

Texas

Another significant development was the announcement by Total Minerals, operator of the Total/Malapai joint-venture uranium property at El Mesquite, that it would restart the project. The ISL project was restarted on August 20 to establish production costs after a lengthy period of standby status. The El Mesquite mine is located approximately 100 miles west of Corpus Christi and contains about 3 million pounds of recoverable reserves at an average grade of 0.10 % U_3O_8. Total Minerals also continued exploratory drilling at its Alta Mesa site.

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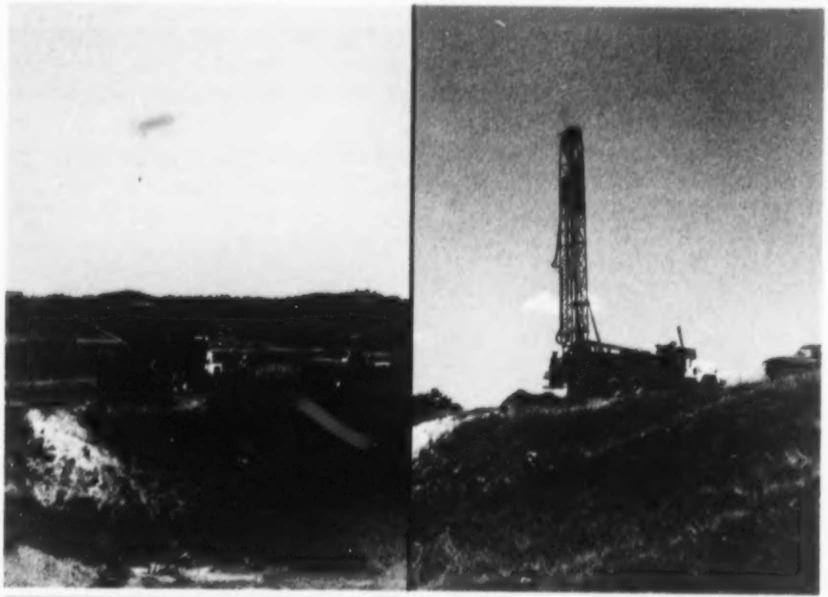

Figure 10 — Ferret's Crow Butte Project. Setting up and operating a drilling rig during the exploratory drilling program at the site. *(Photo courtesy of Ferret Exploration of Nebraska)*

Wyoming

Also in August, Total/Malapai restarted its ISL production at Christensen Ranch. The site, located in the northern Powder River Basin, contains 17.6 million pounds of recoverable reserves at an average grade of 0.116 % U_3O_8. In other areas of Wyoming, some exploratory work occurred at the Green Mountain site, under the joint venture between US Energy Corporation and Kennecott Corporation.

Consolidations

Among the many consolidations in the US uranium industry in 1991, was the Chevron announcement in June that a definitive agreement had been reached with General Atomics (GA) of San Diego, California, whereby GA purchased all of Chevron's uranium assets in the USA and Canada. These assets include the Panna Maria uranium mill, a 55-percent share of the Rhode Ranch uranium mine in south Texas, the Mt. Taylor uranium mine in New Mexico (the largest known uranium deposit in the USA), and exploration properties in Saskatchewan, Canada. Terms of the GA-Chevron agreement were not released. Along with Unocal's sale of its Sweetwater property in 1991, the agreements mark the exit of the last US oil companies from the uranium industry in the USA.

GA also purchased TVA's Powder River Basin uranium properties in Wyoming during May. GA paid $1.6 million for several leases and claims containing reserves estimated at up to 10 million pounds equivalent U_3O_8.

At the end of April, Power Resources Inc. (PRI) acquired all of TVA's *in-situ* leaching properties in the Gas Hills region of Wyoming, with estimated resources of 20 million pounds U_3O_8. TVA retained the open-pit properties in the Gas Hills, which contain uranium resources of up to five million pounds.

In the last quarter of 1991, PRI sold a 25-percent interest in its Gas Hills in-situ leach uranium project to UG Mining Inc., a US subsidiary of Urangesellschaft of Germany. The two companies then formed a joint venture to develop and manage the project, with production planned for 1997. PRI has mineable reserves estimated at about 20 million pounds U_3O_8 at Gas Hills, near Douglas, Wyoming.

Unocal Corporation announced in July that it had agreed to sell its Sweetwater uranium property to the Green Mountain Mining Venture, a joint venture between Kennecott Corporation, and US Energy Corporation and its subsidiary Crested Corporation. The joint venture will purchase the Wyoming property and its mill, and will assume specified environmental liabilities. The purchase will enable the joint venture to use the existing mill to process ore from its nearby Green Mountain project, once it begins operation.

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On January 16, 1991, John Adams, Chairman of Energy Fuels, and Oren L. Benton, owner of NUEXCO, announced a joint venture involving all the uranium operations of Energy Fuels. Energy Fuels, founded in 1972, was the largest US uranium producer during the mid-1980s. Its mining operations, however, are currently on standby. The company holds over 20 million pounds of uranium reserves located in Mojave County, Arizona.

AUSTRALIA

In June, the Australian Labor Party (ALP) voted to maintain its "three-mine policy" that currently precludes development of any other uranium deposits in Australia. This decision, made at the ALP's biennial conference, came as something of a surprise, since prior to the conference, the ALP's own uranium policy review committee and several high-ranking party officials had recommended abandoning the restrictive policy.

In early July, North Broken Hill Peko (NBH) announced its decision to purchase the Jabiluka uranium deposit from Pancontinental for A$125 million. But later in July, Energy Resources of Australia (ERA), 65-percent owned by NBH, announced it, rather than NBH, would purchase Jabiluka. Pancontinental will sell 100 percent of Jabiluka after exercising a 1987 option to acquire Texaco's 35-percent share for A$30 million. The transaction, which was in negotiation for more than six months, will almost certainly result in the eventual processing of Jabiluka ore (estimated to contain more than 450 million pounds equivalent U_3O_8) at ERA's nearby Ranger mill. ERA owns and operates the Ranger facility, approximately 15 km from the Jabiluka site. Although development of the ore body is not expected in the near future, given the necessary changes in governmental policy, development of Jabiluka is a natural follow-on once the existing Ranger deposits are exhausted.

Due to the continuation of the government's policy, uranium exploration and development remains at very low levels. Some drilling was conducted at the Kintyre deposit in Western Australia to further explore, define, and evaluate the deposit, but most exploration activity in Australia has ceased until government policies change.

AFRICA

Throughout Africa, uranium exploration activity has virtually ceased. No major exploration programs outside existing production centers were conducted in 1991. Low market prices have led to cutbacks and closures of some existing production centers; thus increased exploration activity is not expected to occur in the near future.

ASIA

In China, several thousand people are employed in the uranium exploration industry and are busy detailing the several hundred known deposits in the country. While most of the deposits are fairly small, and are of low- to moderate-grade, the cumulative resources and production capability in the country are substantial.

India maintains a large on-going uranium exploration program to locate deposits for use in fulfilling the country's domestic nuclear fuel requirements. During 1991, India's Department of Atomic Energy announced the discovery of a major deposit at Domiasat, in the state of Meghalaya. The sandstone-type deposit is the largest and richest known deposit in the country, with ore grades reaching as high as 0.41 $^{w}/_{o}$ U_3O_8.

CONCLUSION

Low demand and excess inventories remain the most important influence on the uranium market. Consequently, exploration and development will maintain merely a subsistence level of activity. With such limited activity, the major factors affecting the exploration industry will be consolidations and company reorganizations. The need for new resources will increase as inventories decrease, but the emergence of new sources of supply, such as material from dismantled weapons, could slow the rate at which inventories are drawn down. As a result, the exploration and development branch of the uranium industry must simply wait for an increase in demand before it can again be a growing segment of the industry.

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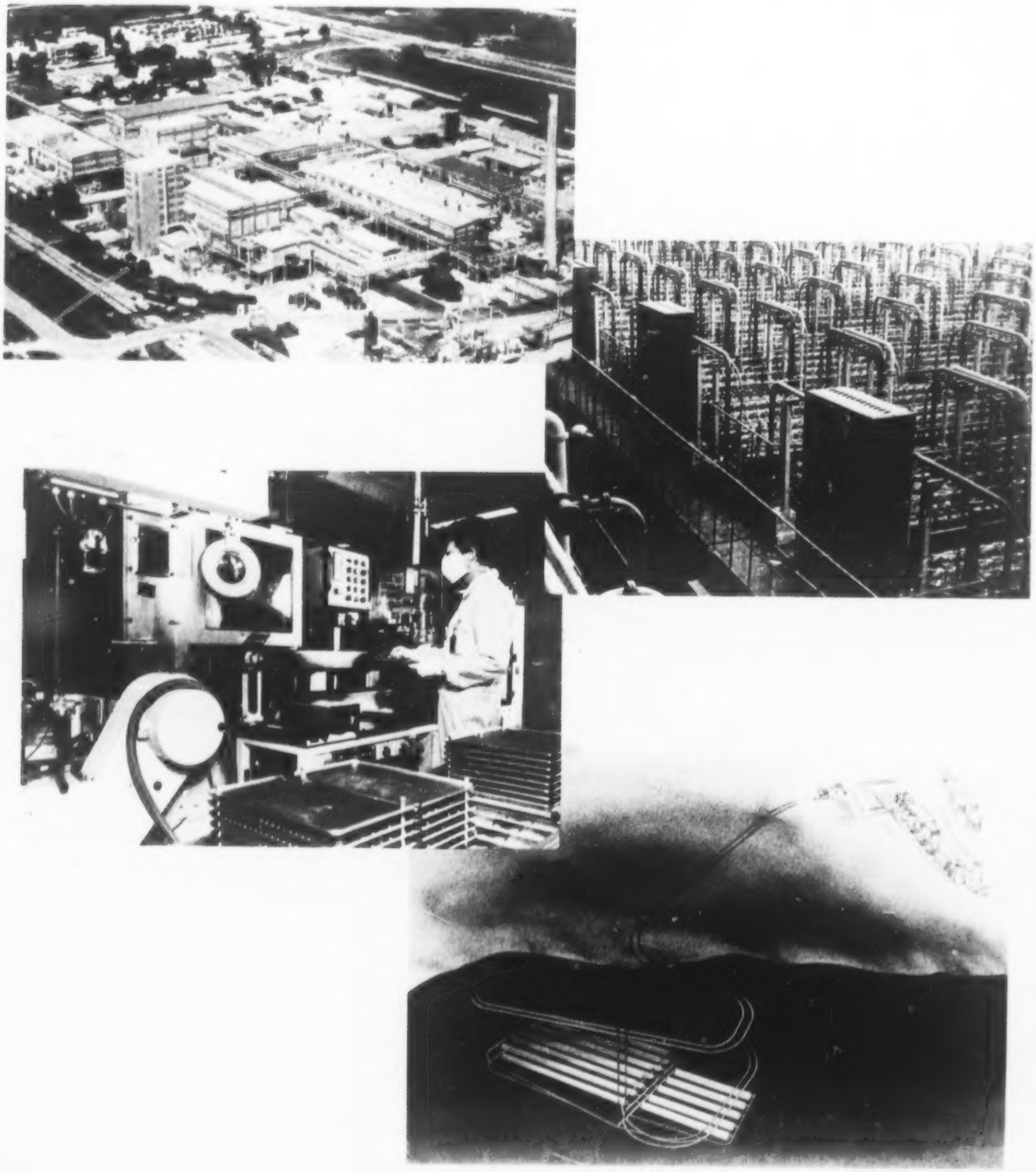
FUEL CYCLE DEVELOPMENTS



CONVERSION

The conversion of uranium concentrates to uranium hexafluoride (UF_6) is performed by six primary converters. Because it represents only about three percent of fuel cycle costs and less than one percent of electricity costs, the conversion process often is overlooked. Currently, conversion capacity greatly exceeds demand in the near term, and inventories held by both converters and utilities exacerbate this supply/demand imbalance.

The full-scale, primary commercial suppliers of conversion services transform uranium ore concentrates to either uranium hexafluoride, ceramic grade uranium dioxide (UO_2), or uranium metal. Three are in North America—Allied-Signal Inc., Cameco, and Sequoyah Fuels Corporation (a subsidiary of General Atomics); two, in western Europe—British Nuclear Fuels plc (BNFL), and Comurhex; and Angarsk, the conversion and enrichment plant in Russia. **Table 11** gives the year of plant start-up, location, process type, nameplate capacity, and estimated 1991 production.

There are a number of small or pilot conversion facilities either operating or about to operate in countries developing their own indigenous fuel cycle facilities. In Japan, at the Ningyo Toge Works, a 200 MTU-per-year pilot plant is serving as the basis for the possible construction of a 2,000 MTU commercial plant by the end of this decade. Brazil and South Africa have plans to complete conversion facilities to support their new enrichment plants by the mid-1990s.

REGULATORY ENVIRONMENT

Of the conversion market developments that occurred in 1991, the most important event was the NRC-mandated shutdown of Sequoyah Fuels Corporation's (SFC) conversion facility near Gore, Oklahoma, after a series of incidents at the plant.

On October 4, 1991, NRC issued an order preventing the SFC plant from restarting. The plant had been shut down since September 20 for annual maintenance and inspection,

Table 11
WORLD CONVERSION SUPPLIERS

Supplier	Year Operational	UF_6 Conversion Location	Process	Nameplate Capacity (MTU/Year)	1991 Estimated Production (MTU)
Allied Signal, Inc.	1959	Metropolis, Illinois, USA	Dry Fluoride Volatility	12,600	7,000
British Nuclear Fuels plc	Early 1950s	Springfields, United Kingdom	Wet Solvent Extraction	6,000	5,000
Comurhex	1962	Pierrelatte, France	Wet Solvent Extraction	14,000	9,500
Cameco	1970	Port Hope, Ontario Canada	Wet Solvent Extraction	10,500	6,700
Sequoyah Fuels Corp.	1970	Gore, Oklahoma, USA	Wet Solvent Extraction	9,100	5,500
Russia	1965	Angarsk	Flame Reactor	22,000	11,100
TOTAL				**74,200**	**44,800**

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and was scheduled to restart on October 6. While conducting a series of inspections sparked by an August 1990 incident, in which SFC had discovered radioactive water leaks that had occurred in the 1970s, NRC discovered other safety violations and regulatory problems at the plant. In response to NRC directives, SFC published a press release announcing a broad-based improvement program, including an in-depth operational review by outside consultants, management restructuring, and improved environmental and safety programs. NRC has continued to scrutinize closely SFC activities. Due to several concerns, the plant has not yet been permitted to restart, although SFC is confident it will be able to reopen within a few months.

In 1988, General Atomics (GA) purchased the conversion operations of SFC from the Kerr-McGee Corporation. Sequoyah uses a wet solvent extraction process. The original plant capacity was 4,500 MTU, but in 1979 Sequoyah expanded its nameplate capacity to 9,100 MTU and introduced equipment capable of processing slurry forms of uranium concentrates that are becoming more prevalent due to the increasing use of alternative recovery methods (mostly solution mining). The conversion of slurry through the wet process eliminates the need for drying and packaging slurry at the milling site. Production for 1991 totalled only 5,500 MTU, as a result of the shutdown mandated by the NRC. So far the prolonged closure of the SFC plant has had little or no impact on the market: only a few utilities seemed to be concerned about Sequoyah not being able to make deliveries. However if the shutdown should be extended into late 1992, the impact on the market could become noticeable.

A controversial regulatory development affecting the conversion market was an NRC proposal to assess annual user fees on fuel cycle and materials licensees. For converters, the annual fee per facility is expected to range between $300 thousand and $2.3 million, depending upon the type of license. The fees will be used to support NRC's operating budget, which the US Congress mandated be supported by income from customers that NRC regulates. Several converters are disputing the charges, which would result in higher prices for primary conversion services.

SUPPLY AND DEMAND

As in previous years, the conversion market during 1991 was characterized by oversupply. World conversion production capacity currently exceeds conversion demand by about 30 percent annually. In addition to the Sequoyah shutdown, all the other primary converters currently are operating well below capacity. Inventories built up over time by utilities are being reduced and have resulted in declining sales. When combined with the UF_6 inventories held at conversion plants, the lack of demand has caused converters to operate at substantially less than nameplate capacity for more than six years. The inventories held by primary converters cloud the supply/demand situation in that the size of the stockpiles is undetermined. These inventories have been shifting in recent years, as most suppliers are gradually drawing down their inventories, particularly in the Western World.

UF_6 inventories held by US utilities are quite large, as a result of fixed quantity, long-term contracts, and in part, to utility inventory policies. Recently, utilities, particularly in the USA, have been moving toward shorter contracting periods and lower or zero inventory levels; thus inventories have been declining gradually over the past few years as utilities work off their existing stock. This trend is expected to continue as old conversion contracts expire and new contracts are negotiated with increased quantity and delivery flexibility. Worldwide natural UF_6 inventories also are expected to decline steadily in the future. Nevertheless, overcapacity is projected to extend into the next century.

The other major factor that may affect the long-term conversion market is the commercial development of the AVLIS enrichment process. The uranium feed envisioned for the AVLIS process is uranium metal, which could change the whole nature of the conversion business in the next century. Use of the AVLIS technology would require major investment in new facilities in parallel with significant write-downs of existing conversion facilities. The final costs of these realignments undoubtedly would be borne by the utilities.

NEW CAPACITY

BNFL is the only primary converter planning to commission a new conversion facility within the next few years. From the former production group of the United Kingdom Atomic Energy Authority, BNFL was created in 1971 as a private, limited company. The entity became a public, limited company in 1984, and all shares are now owned by the British government. The company converts natural uranium concentrates to UF_6 at its plant in Lancashire, England. In addition to UF_6 conversion, BNFL provides UO_2 conversion, fuel fabrication, reprocessing, and waste management, as well as enrichment through its ownership share in Urenco's Capenhurst plant. BNFL has announced that it will commission a new conversion plant in 1993 with an annual capacity of 6,000 MTU. BNFL's operating level in 1991 was approximately 5,000 MTU. The company exports UF_6 to the USA, Europe, and Asia.

In September 1984, Japan announced that a full-scale commercial conversion facility will be built at the Rokkashomura nuclear fuel cycle complex in the Aomori Prefecture on the northern end of Honshu Island. Its capacity, which has not been established at this time, is expected to be tied to the capability of the commercial enrichment plant, although it is unlikely this facility will come into operation before the year 2000.

CURRENT SUPPLY

In addition to Sequoyah, the other US-based converter is Allied-Signal, Inc. Allied began converting uranium concentrates at its plant in Metropolis, Illinois, in 1959. Its nameplate capacity of 12,600 MTU per year is based on full use of the facility for uranium hexafluoride. The facility can and does also produce other chemicals, with a corresponding reduction in UF_6 capability.

Cameco is engaged in uranium exploration, mining, milling, and refining, as well as conversion. Cameco refines natural uranium concentrates to UO_3 at its Blind River, Ontario, facility and then converts the UO_3 either to UF_6 destined for eventual enrichment or to UO_2 for use in Canadian heavy water (CANDU) reactors. Its Port Hope, Ontario, plant has a nameplate capacity of 10,500 MTU annually; the facility also is capable of producing 2,500 metric tons of uranium metal per year. Cameco utilizes a wet solvent extraction process, with modifications that allow for recovery of hydrofluoric acid, which substantially reduces the volume of residue generated in UF_6 conversion.

Incorporated in 1971, Comurhex operates uranium conversion facilities with a total nameplate capacity of approximately 14,000 MTU as UF_6 per year, ranking it first in capacity among the five converters outside Russia. Its facilities are located at two sites: one near Narbonne on the Mediterranean Coast, and the other at the Pierrelatte nuclear fuel cycle complex on the Rhone River south of Lyon (**Figure 11**). The first is designed to produce uranium tetrafluoride (UF_4) and uranium metal, and the latter produces fluorine (F_2) and uranium hexafluoride. France's large domestic requirements allow Comurhex to maintain a significant base-load capacity: more than half its load is destined for Electricité de France, and the rest for customers located primarily in Europe and Asia. Production for 1991 is estimated to be near 9,500 MTU. Currently, Uranium Pechiney holds a 51-percent share of Comurhex; Cogema owns the balance.

Russia has the largest conversion capacity in the world: the country's known conversion facility operates at Angarsk, with a nameplate capacity of 22 thousand MTU per year. The former Soviet Union began developing UF_6 conversion technology in 1947. Initially, the technology was based upon direct fluorination of mixed uranium oxide in single-tube horizontal reactors equipped with mixers, but it was inefficient compared to fluorination of UF_4, a process that was being developed in parallel. That process was based on a sulfate system, which included dissolving U_3O_8 in sulfuric acid, the electrolytic regeneration of uranyl sulfate, and at the final stage, hydrofluorination. The fluorination of UF_4 used horizontal tube reactors, which had a production capability of 1.0 to 1.2 tons per hour.

In 1956, the introduction of twin-tube fluorinators improved the utilization of fluorine and increased production capacity to 2.5-8.0 tons UF_6 per hour. In 1965, the introduction of flame reactors (fluorination in dust infusions) made possible the fluorination of both UF_4 and uranium oxides. Design of the first generation of flame reactors included air-cooled retorts. Subsequently, water-cooled retorts were developed and introduced, thereby improving productivity.

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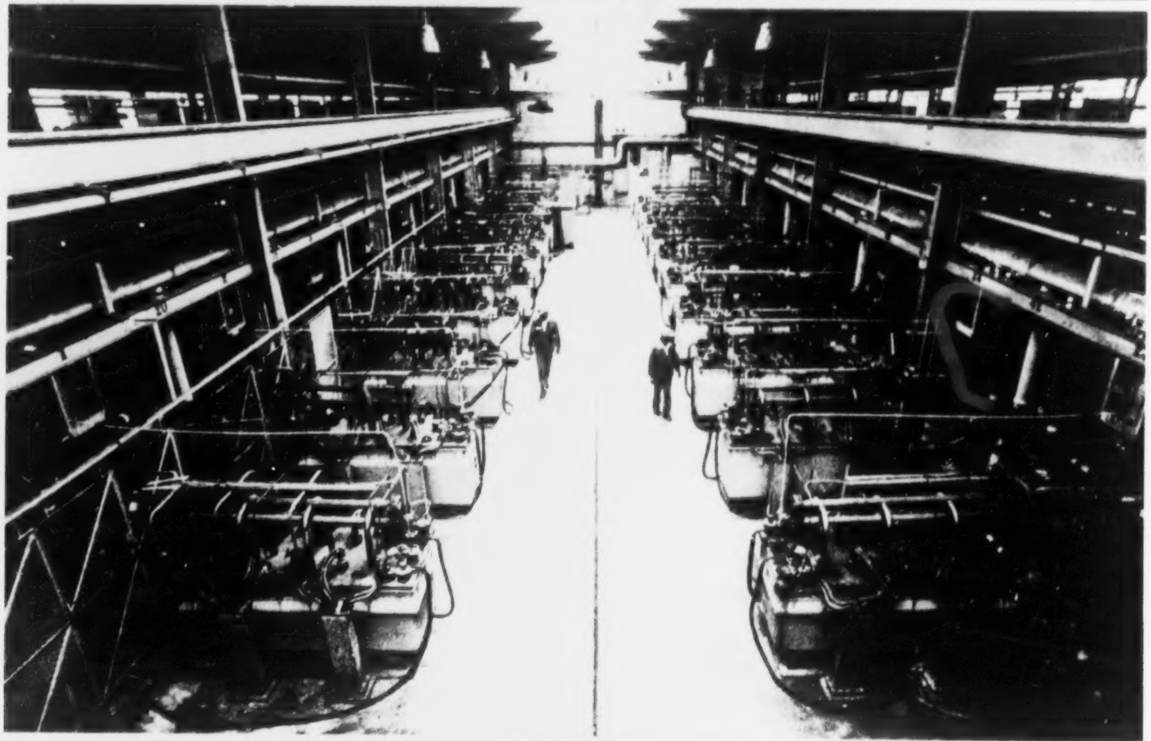

Figure 11 — Comurhex's Pierrelatte Conversion Plant. Interior view of the plant, located south of Lyon, France. *(Photo courtesy of Comhurex)*

OTHER SUPPLIERS

The Power Reactor and Nuclear Fuel Development Corporation (PNC) of Japan has been engaged in the development of an integrated refining and conversion technology based on the wet-process method. This process can produce reactor-grade UF_4 directly from uranium ore and then convert it into UF_6 without the intermediate stage of yellowcake production. It can also be used to convert yellowcake material into UF_6. The technology has been demonstrated in PNC's pilot plant at the Ningyo Toge Works, where Japan's pilot uranium enrichment centrifuge plant is also located. The pilot conversion plant, which has an annual capacity of 200 MTU, has been operating since March 1982.

The Institute of Nuclear Energy Research of Brazil opened a 90 MTU-per-year pilot conversion plant in 1984. Empresas Nucleares Brasileiras S.A. (Nuclebras) had ordered a 2,000 MTU per-year conversion facility from Pechiney to be built at the Rezende nuclear fuel center where Brazilian facilities for enrichment and fabrication are located. The new plant originally was scheduled to begin operation in October 1984, but has been delayed indefinitely. Brazil currently has no plans to operate a commercial conversion facility unless domestic demand reaches a level allowing economic operation of such a plant.

ENRICHMENT

A resurgence of interest by utilities in the uranium enrichment market occurred in 1991, as a result of marketing efforts by primary suppliers, in particular, the US Department of Energy (DOE) and Techsnabexport. Price, contract flexibility, and reliability of supply were the dominant factors governing utility purchase considerations. A large number of US utilities sought to diversify their enrichment supply sources for economic reasons. Consequently, the enrichment market experienced its highest level of activity since the introduction of DOE's Utility Services Contract in the mid-1980s. Twenty-five new long-term enrichment contracts were signed in 1991, many at attractive prices. Low spot market prices have pressured major suppliers to become more competitive and offer attractive prices in the long-term market.

The market for unfilled utility requirements in the USA remains appealing for major suppliers. Although Eurodif and Urenco have been disadvantaged by exchange rate considerations, all of the primary suppliers have focused on the post-1995 time period, especially in the USA, where large unfilled requirements remain. DOE's success in capturing a significant portion of this unfilled demand, proves it can be competitive. Additionally, the emergence and success of GNSS as an alternative supplier indicates buyer willingness to explore new supply sources. However, the future success of all enrichment suppliers will depend on their ability to adapt to changing market conditions by reducing excess capacity, controlling costs, and appealing to utilities with competitive contracting terms.

US DEPARTMENT OF ENERGY (DOE)

At the end of 1991, DOE remained the world's largest supplier of enrichment services. Sales of DOE enrichment services are estimated at about 40 percent of total world requirements; however, most of these sales are based on the Utility Services Contract (USC) and the sales incentives negotiated with customers over five years ago. On April 1, 1991, 30 US utilities opted to terminate 100 percent of their requirements in 2000, and 31 US utilities terminated 100 percent for 2001. Of those utilities that remained with DOE in 2000 and 2001, the majority committed 70 percent or less to DOE.

As a result of these reductions and a concern over increasing competitive pressures, DOE's marketing efforts in 1991 escalated to levels not seen since 1985. By offering customers prices below the USC base price, DOE significantly increased its post-1995 market share. About eleven US customers committed to purchase up to 30 percent of their remaining unfilled requirements from FY1996 through FY1998. DOE's marketing of this "IP-3" appears to be similar to past incentive price offerings, where a lower price is offered to customers using marginal cost production from the gaseous diffusion enrichment plants. However, in this case, DOE offered additional contract flexibilities to some customers on their 70-percent coverage, as an added incentive to buy its SWU. Overall, it appears the Department's action has reduced the percent of world unfilled requirements from 1996 through 1998 by about 13 percent and reduced unfilled demand in the USA by at least 20 percent.

DOE also has approached several of its US customers with a "SWU for Power" arrangement, whereby a customer can receive SWU credits in return for supplying DOE with electric power for the gaseous diffusion plants (GDP). Such an arrangement allows a utility to deliver power to DOE at a cost that would be lower than the cost of purchasing SWU directly at DOE prices.

On April 3, DOE announced its price for enrichment services under the USC for fiscal year 1992. The price increased by 3.1 percent to $121.50 per SWU. The IP-2 price also increased, rising by about 4 percent, to $104.67 per SWU, based on the GNP Implicit Price Deflator.

Operations

DOE's production in fiscal year 1991 totalled about 11 million SWU. This is less than its planned 1991 production of 12.4 million SWU, the figure provided by the Department in its Congressional budget request. Based on this request, it is estimated that DOE's per SWU operating cost would have been slightly less than $90 per SWU. As reflected in past years, DOE continued to maintain a "split-tails" mode of operation, using its inventory of natural uranium to overfeed the enrichment plants by operating at a higher tails assay than the transaction tails assay being used by its customers.

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Although more uranium is fed into the plants, energy savings are realized by using less SWU.

The continued availability of low-cost power, coupled with relatively low SWU production levels, allowed DOE to produce lower-cost SWU during 1991. DOE offered some customers the opportunity to adjust their transaction tails assay for upcoming deliveries to take advantage of the lower-cost production, which subsequently provided DOE the benefit of slightly higher revenues.

In November, DOE announced that it would suspend production of highly enriched uranium (HEU) for US naval fuel and other commercial uses. DOE made this decision after considering the availability of surplus materials and planned reductions in the number of nuclear weapons in the country's defense stockpile. Compliance with safety rules and regulations will require interim production at a minimum rate to ensure that shutdown can be executed in a safe and environmentally sound manner. It will take approximately three years to complete the process of placing the HEU production portion (also called the "Top") of the Portsmouth GDP in stand-by. At that time, DOE will decide whether to maintain the Top in stand-by or to shut it down permanently. Starting in FY 1993, virtually 100 percent of the production from the enrichment plants will be used to meet commercial sales.

TECHSNABEXPORT

Russia has four known enrichment plants with an estimated total capacity of at least ten million SWU (**Table 12**). The plants utilize centrifuge technology, and one plant, at Tomsk, has entered into an agreement with a Western company to enrich reprocessed fuel. The Ministry of Atomic Energy of the Russian Federation (Minatom) operates the four plants located at Ekaterinburg, Angarsk, Krasnoyarsk, and Tomsk. The first centrifuge pilot plant went into operation in the former Soviet Union in October 1957. The first industrial unit entered operation in 1959, with a full-scale plant based on three modules built between 1962 and 1964.

Techsnabexport (TENEX) is the marketing agent for the enrichment services of Minatom. TENEX presently services all contracts with east European countries having nuclear programs and has contracts with a number of Western utilities as well. The company has indicated it could export as much as 10 million SWU annually by the year 2000. During 1989, TENEX began supplying EUP (using Soviet origin uranium) to the Western market, in addition to SWU. In June 1991, it announced a joint venture with NUEXCO Exchange AG, to market nuclear fuel products and services. The joint venture, called Global Nuclear Services and Supply, Ltd. (GNSS) actively marketed SWU and EUP to utilities during 1991, and at present, has executed agreements with two US utilities for long-term supply.

EURODIF

Eurodif currently supplies about 20 percent of the world's utility requirements. Reports indicate that the Georges Besse gaseous diffusion plant operated at about 60 percent of its capacity during 1991. Eurodif and its marketing agent Cogema do not appear to have signed any new enrichment contracts in the USA in 1991, and remain primarily a European and Asian supplier.

In late 1991, Eurodif settled its long-standing dispute with Iran after thirteen years. On December 29, France and Iran signed a settlement resolving the lawsuits between Eurodif and Iran as shareholders in Sofidif. The lawsuits stem from the Iranian Islamic revolution in 1979 and that government's decision to stop taking its share of Eurodif's output and refusal to pay its share of operating expenses, as well as the US$1 billion loan from Iran to Eurodif in 1974, that had not been repaid to Iran. Although specific terms of the agreement are not available, it appears that the settlement will cost the French government some FF13 billion (US$2.6 billion); France will pay Iran about FF5 billion of the total by the end of 1992. Under the terms of this settlement, Eurodif will be reimbursed for its past losses by receiving more than five billion francs in damages resulting from Iran's failure to accept and pay for its share of production during the 1980s. Eurodif then will repay the Iranian loan with interest, as well as other advances received from Iran's Atomic Energy Organization, amounting to about FF1.6 billion.

Provided with the net infusion of money from the settlement, Eurodif can now improve its financial position and reduce its liabilities. The terms of the settlement do not appear to affect the percent ownership of Eurodif by the shareholders, and Iran maintains its share in Sofidif, the French/Italian consortium.

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URENCO

During 1991, Urenco operated near full capacity, producing about 2.6 million SWU. The company operates three centrifuge enrichment plants: at Capenhurst, UK; Almelo, The Netherlands (**Figure 12**); and Gronau, Germany. In October 1991, the company announced that it would reorganize and merge all its activities under one central management. Combined with a centralized marketing effort, each individual partner has been responsible for its centrifuge development and manufacture, as well as enrichment production. Urenco stated that central management for all activities would allow it to be "better equipped to meet the rapidly changing demands of the enrichment market in the latter half of the 1990s and to maintain and even strengthen its position in this market, which is expected to be characterized by strong competition". Urenco reportedly will establish its central offices in Marlow, England, and likely will trim its current staffing levels.

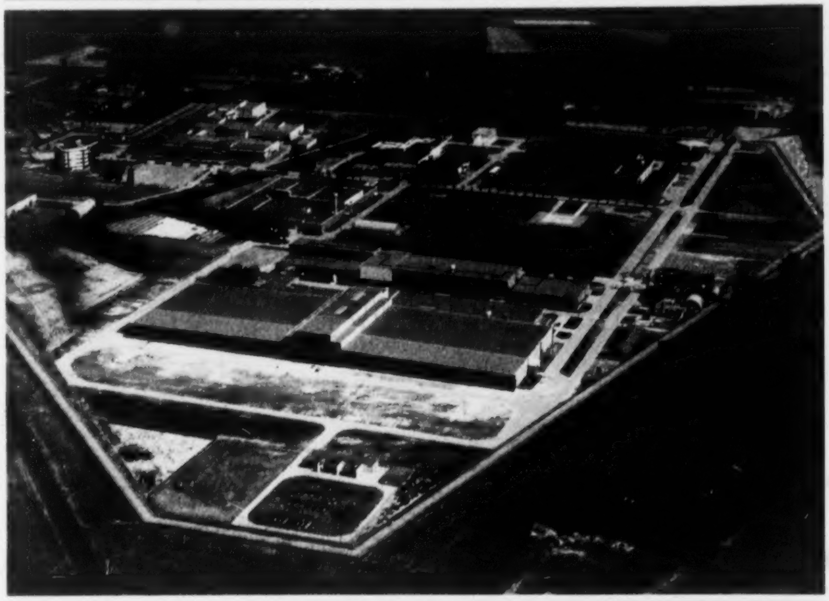

Figure 12 — Urenco Enrichment Plant. Located at Almelo, The Netherlands, this centrifuge plant has a 1.5 million SWU/year capacity. (*Photo courtesy of Urenco*)

LOUISIANA ENERGY SERVICES

The first major milestone for the Urenco-led consortium, Louisiana Energy Systems (LES), was completed at the end of January 1991, when LES filed its license application with the NRC for construction and operation of the plant. Licensing work has been shared by consortium members Duke Engineering and Fluor Daniel. LES is now in the process of obtaining financing for construction of the plant and long-term contracts for its production. During 1991, LES appeared to have had some difficulty marketing its SWU in the USA, reportedly because of its requirement that the contract duration be 10 years.

Anti-nuclear groups in Claiborne Parish, Louisiana have expressed concerns about the safety of the LES facility, and have questioned the lack of public participation in the licensing process. The NRC's Atomic Safety and Licensing Board has called for a hearing to review the intervenors' complaints. Among the issues the Board recommended for consideration are the need for analysis in accordance with the National Environmental Policy Act, and the reasonableness of the decommissioning and decontamination funding plans.

JAPAN NUCLEAR FUEL INDUSTRIES

Japan Nuclear Fuel Industries' (JNFI) centrifuge enrichment plant at Rokkashomura, Aomori Prefecture, concluded a safety agreement with the Aomori and Rokkashomura governments in late July 1991, thereby permitting the plant to begin operation. JNFI received final national approval in late May 1991, when the Science and Technology Agency issued a facility inspection certificate, permitting an initial operating capacity of 150 thousand SWU per year. The plant began test operations in 1990 and commercial operation in early 1992. Initial output from the plant will be sold to domestic utilities.

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Table 12
WORLD ENRICHMENT SUPPLIERS

Supplier	Plant	Enrichment Process	Initial Production Began	Nameplate Capacity (Million SWU/yr)
USDOE	Paducah, Kentucky	Gaseous Diffusion	1954	11.3
	Portsmouth, Ohio	Gaseous Diffusion	1956	7.9
				19.2
TENEX	Ekaterinburg, Russia	Centrifuge	1959[1]	*na*
	Tomsk, Russia	Centrifuge	1959[1]	*na*
	Krasnoyarsk, Russia	Centrifuge	1959[1]	*na*
	Angarsk, Russia	Centrifuge	1959[1]	*na*
				10.0[2]
Eurodif	Georges Besse, France	Gaseous Diffusion	1979	10.8
Urenco	Capenhurst, United Kingdom	Centrifuge	1976	0.7
	Almelo, The Netherlands	Centrifuge	1976	1.5
	Gronau, Germany	Centrifuge	1985	0.5
				2.7
PRC	Lanzhou, People's Republic of China	Gaseous Diffusion	*na*	0.5[3]
South Africa	Valindaba	Helikon	1986	0.3
Japan	Rokkashomura	Centrifuge	1988	0.2
Other	Argentina	Gaseous Diffusion/Centrifuge	1990	*na*
	Brazil	Gaseous Diffusion/Centrifuge	1990	*na*
				0.2
				43.9

na = not available

[1] Russia's pilot centrifuge enrichment plant began production in 1957. Its first industrial centrifuge enrichment plant began production in 1959. The subsequent years that each of the other plants began production is unavailable.

[2] Estimate

[3] The only available production capacity figure for the People's Republic of China is the capacity available for export purposes.

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NEW ENRICHMENT TECHNOLOGIES

AVLIS

DOE's Advanced Vapor Laser Isotope Separation (AVLIS) program, continues to progress toward technology demonstration and evaluation by FY1993. DOE has spent almost two decades and nearly $1.3 billion developing AVLIS; however, during 1991 Lawrence Livermore National Laboratory (LLNL) reported that the project continues on schedule but may experience additional slippage due to budget reductions. LLNL also reported that all major AVLIS systems were in various stages of construction and testing for the demonstration; the copper lasers were producing 9,000 watts of laser light, and the dye lasers were operating at one-half plant power. Should the demonstration be successful, LLNL claims that a small AVLIS plant of about four million SWU capacity can be ready for commercial deployment as early as 1997. LLNL still projects a "factory cost" of about $25 to $50 per SWU, which includes all capital outlay and depreciation. The maximum assay of the plant would be 5.0 $^{w}/_{o}$ ^{235}U, with a tails assay of 0.10 $^{w}/_{o}$ ^{235}U. In preparation for deployment, LLNL is preparing the NRC licensing application.

A study of other potential applications of AVLIS technology was conducted in 1991 by the National Academy of Sciences. The study identified several areas of potential application, including reduction of nuclear waste through re-enrichment and refined chemical processing, isotope separation of burnable neutron absorbers to improve economics and safety in the nuclear industry, and laser material processing to improve industrial manufacturing technology.

SILVA

Commissariat a l'Energie Atomique stated that France is on schedule to build and operate an industrial prototype of the SILVA enrichment process by 1995. The first plant module will be constructed during the years 2000 to 2005, with plant deployment during the 2005 to 2010 timeframe. The cost of producing SWU from SILVA is projected to be about $60 per SWU.

CRISLA

In 1990, Isotope Technologies announced it had formed a Canadian joint venture called CRISLA Technologies, with Cameco and Agra Industries (a large Canadian architectural-engineering firm), to develop the Chemical Reaction by Isotope Selective Laser Activation (CRISLA) process. CRISLA Technologies continues to develop its enrichment process and apparently has achieved good separation results. Work on process scale-up is proceeding with near-term effort focused on separator chamber design and performance. Encouraging results have led to an increased budget in 1992 for CRISLA, in anticipation of completing work at the current intermediate scale and preparing for commercial-scale-module demonstration. CRISLA Technologies' goal is to initiate commercial production by 1996. The company continued to market its services to utilities in 1991 and has contracted with one US utility to deliver enrichment services starting in 1996.

FABRICATION

Several developments occurred in the fuel fabrication industry in 1991, ranging from substantial sales contracts, to new fuel designs, to potential criticality problems. The potential for assessment of new NRC user fees and increased NRC regulation may have a significant affect on US fabricators within the next few years, and in turn, may affect the price of US fuel fabrication services throughout the nuclear industry. **Table 13** lists LWR fuel fabrication companies, factory locations, and manufacturing capacities for BWR and PWR fuel assemblies.

SALES

Three notable contracts involving fabrication were signed in 1991, including one of the largest commercial deals ever signed, in which British Nuclear Fuels plc (BNFL) agreed in September to provide US$22 billion of nuclear fuel services to Nuclear Electric over the next 15 years. The contracts are effective from April 1989 and include fuel supply to Magnox and AGRs, reprocessing, and radioactive waste treatment and storage. BNFL also obtained its first mixed oxide (MOX) fuel order in 1991, signing a contract with NOK of Switzerland to supply 28 PWR fuel assemblies for Beznau 1 over several years starting in 1993. The fuel will be fabricated at the MOX Demonstration Facility at Sellafield.

In another important sale, Electricité de France (EdF) placed an order with ABB-Atom for reload fuel for some of France's 1,300 MWe PWRs. The fuel will be an advanced 17 x 17 design manufactured at the ABB-Atom plant in Västerås, Sweden. Deliveries from 1992 through 1996 include lead assemblies, demonstration assemblies, and two reloads of fuel assemblies.

Coincident with the Eurodif settlement in late 1991, Framatome and Iran's Atomic Energy Organization reached an agreement regarding the cancellation of their nuclear fuel supply contract. The International Chamber of Commerce in Lausanne, Switzerland rendered the judgement on the contract for Iran's cancelled Karun nuclear power plant. The settlement will cost Framatome US$110 million, composed of nearly equal parts of Iran's down payment and interest.

FUEL ORGANIZATIONS

Like other areas of the fuel cycle, the fabrication industry also has been undergoing reorganization aimed at improving competitiveness and consolidating the scope of operations. On November 21, 1991, Westinghouse, BNFL, and ENUSA, announced that they had formed the European Fuel Group (EFG). The alliance is a marketing, design, and manufacturing group for PWR fuel in the European market. By pooling resources, EFG hopes to successfully compete with Siemens, Fragema, and ABB. BNFL brings to EFG the capability to fabricate MOX and reprocessed uranium fuel. ENUSA and BNFL are both PWR fuel fabrication licensees of Westinghouse (**Figure 13**).

In an effort to better manage its international operations, BNFL formed a new subsidiary, International Nuclear Fuels, Ltd. (INFL), to operate its twelve overseas nuclear-oriented businesses, such as BNFL Inc. of the USA, Centec, and Pacific Nuclear Transport, Ltd. Eventually, INFL may include equity participation by overseas partners. INFL recently signed its first sales contract with Siemens Nuclear Power Corporation's fuel fabrication plant in Lingen, Germany, for the conversion of enriched UF_6 to UO_2 at BNFL.

Also during the past year, the French increased their ownership interest in the Babcock and Wilcox nuclear businesses. The US subsidiaries of Framatome, Cogema, and Uranium Pechiney expanded their cumulative interest in the B&W Fuel Company from 49 percent to 75 percent, and Framatome expanded its ownership of the B&W Nuclear Service Company from 50 percent to 75 percent.

Siemens also reorganized during 1991, consolidating and renaming its nuclear organizations in the USA and Europe. Nuclear activities in the USA have been consolidated under the name Siemens Nuclear Power Corporation. This includes the former Advanced Nuclear Fuels Corporation (ANF), the former Universal Testing Laboratories, Inc., the newly acquired Qual-Tec Testing Services, Inc., and the services of the (now defunct) Bechtel-KWU Alliance. In Europe, the former ANF will operate under Siemens Nuclear Power Corporation as two subsidiaries: Advanced Nuclear Fuels International, Inc., with business offices in Europe and Asia; and Advanced Nuclear Fuels GmbH, the operator of the fuel manufacturing plant at Lingen, Germany.

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Table 13
WORLD FUEL FABRICATION FACILITIES

Production Company	Factory Locations	Reported Capacity (MTU per year)		
		BWR	PWR	TOTAL
USA		**1,300**	**2,600**	**3,900**[1]
ABB-Combustion Engineering	Lynchburg, Virginia			
B&W Fuel Co.	Windsor, Connecticut			
General Electric Co.	Wilmington, N. Carolina			
Siemens Nuclear Power Corp.	Richland, Washington			
Westinghouse Electric Corp.	Columbia, S. Carolina			
EUROPE		**950**	**4,650**	**5,600**[1]
ABB Atom	Västerås, Sweden			
Advanced Nuclear Fuels GmbH (Siemens)				
Kraftwerk Union	Lingen, Germany			
RBU-1	Hanau, Germany			
RBU-2	Karlstein, Germany			
British Nuclear Fuels plc	Springfields Works, Great Britain			
ENUSA	Juzbado, Spain			
FBFC	Dressel, Belgium			
	Romans, France			
	Pierrelatte, France			
Russia	Undisclosed			
ASIA		**950**	**955**	**1,905**[1]
Mitsubishi Nuclear Fuel	Tokaimura, Japan			
Japan Nuclear Fuel Company	Kurihama, Japan			
Japan Nuclear Fuel Industries	Kumatori, Japan			
	Tokaimura, Japan			
Korea Nuclear Fuel Company	Daeduk-Danji, S. Korea			
China National Nuclear Corp.	Yibin, Sichuan Province, China			
OTHER		**25**	**175**	**200**
Industrias Nucleares do Brasil	Rezende, Brazil			
Nuclear Fuel Complex	Hyderabad, India			
Atomic Energy Corporation	Pelindaba, S. Africa			
TOTAL		**3,225**	**8,380**	**11,605**

[1] Total capacity as announced; BWR/PWR split estimated (and probably variable).

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Figure 13 — Fuel Fabrication at ENUSA's Juzbado facility. (*Photo courtesy of ENUSA*)

Several other fabricators worldwide announced changes in their facilities as well.

- The Chinese nuclear fuel factory at Yibin in Sichuan province will build the fuel assemblies for Daya Bay 1 and 2, as the result of an agreement signed in May 1991 to transfer PWR technology from Framatome to the China National Nuclear Corporation (CNNC). In addition, new fuel designed by the Pakistan Atomic Energy Commission for the PARR 1 research reactor will be fabricated at the Chinese factory, due to lower prices than those in Pakistan.
- The uranium processing work of ABB-Combustion Engineering related to nuclear fuel fabrication will be consolidated at the Hematite, Missouri, plant by 1993. Formerly, the plant at Windsor, Connecticut, loaded pellets in fuel rods and assembled bundles. Nuclear fuel business operations and the manufacture of some fuel assembly components will remain at the Windsor site.
- India's Department of Atomic Energy plans to increase the UO_2 pellet production capacity and build an assembly facility at its Hyderabad plant. It will also commission a Zircaloy fabrication plant and build a zirconium sponge plant. These activities are planned over the next ten years and represent investments of approximately US$270 million.
- A high-temperature evaporation process for producing nuclear grade zirconium proved too expensive for South Africa. Therefore, a factory at the integrated Pelindaba site has been closed and replaced with the more conventional Zircaloy tubing extrusion process.

FUEL DESIGNS

Fuel designs continued to evolve and be refined in the past year. Fragema announced a modern fuel design for Soviet-designed VVER reactors. It is based on Fragema's Advanced Fuel Assembly bundle design for PWR fuel. Fragema reportedly wants to develop a fuel fabrication facility in Europe and is seeking partners.

General Electric has responded to utility requests by offering a new fuel design, *GE12*, a 10 x 10 rod bundle providing lower duty for the fuel rods and higher uranium content, aimed at reducing fuel cycle costs. GE also announced *GE13*, a 9 x 9 rod bundle with improved critical power capabilities aimed at uprating reactor power.

Westinghouse delivered the first several bundles of VANTAGE+ fuel to a utility in 1991. In addition to many state-of-the-art features, VANTAGE+ includes an advanced Zircaloy cladding material containing niobium.

Siemens announced that four Atrium bundles are to operate in a German BWR reactor. The new Siemens/Kraftwerk Union BWR bundle has a square, internal, non-boiling water channel. This design, like the Siemens Focus design for PWR fuel, increases burnup and operating margins.

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INDUSTRY DEVELOPMENTS

In April 1991, the NRC proposed assessing annual user fees on fuel cycle and materials licensees, including nuclear fuel fabricators. The annual fees for conversion and fabrication plants are expected to be between $300 thousand and $2.3 million per facility depending upon the type of license, and will be used to support the NRC's operating budget. This is part of a proposal to increase reactor license fees and add fees for nuclear activities such as export and import licenses, transportation, quality assurance, generic uranium activities, and cleanup.

The fabrication industry also has kept a close watch on the development of AVLIS, since the uranium metal product of this enrichment process is not compatible with the current commercial methods of fabricating nuclear fuel assemblies. Fabricators currently accept enriched UF_6 into their plants and convert it to UO_2, which is pelletized, sintered, ground, clad, and assembled in bundles. A process to convert uranium metal to UF_6, or to UO_3 which some fabricators can accept, needs to be added to the nuclear fuel cycle. Fabricators have hesitated to invest in such additions until a decision is made to build an AVLIS plant. Financial investments are needed to link AVLIS to fuel fabrication. Whether DOE, or a privatized enrichment business, or existing fuel cycle companies choose to participate remains to be seen.

Fabrication Facility Incidents

On May 29, 1991, at General Electric's fuel fabrication facility in Wilmington, North Carolina, 150 kilograms of uranium were misrouted to a storage tank where criticality could have occurred. Responding to the event, an NRC incident investigation team (ITT) reported inattention by management to potential criticalities, design deficiencies, procedural non-compliance, inadequate investigations, and deterioration of criticality safety. In addition, the ITT reported deficiencies in the NRC oversight of the facility. As a result, on October 18, 1991, fuel cycle plants and research facilities were issued Bulletin 91-01 dealing with the prevention of degradation of critical controls. In addition, the NRC is working on changes in federal regulations for fuel cycle facilities.

The uranium processing works of Siemens Brennelementewerk Hanau (SBH) restarted on January 6, 1992, after being closed by authorities in December 1991. The closure was ordered due to discovery of non-tested hydrogen lines in the plant, found in inspections after a hydrogen explosion occurred in a nearby non-nuclear plant. Recent tests of the hydrogen lines at SBH were successful and must be repeated every three months. In addition, delays in improving ammonia emissions have focused regulatory attention on the plant. Since SBH fabricates more than half the fuel used by German nuclear plants, utilities made contingency plans in case the factory was down for an extended time. Power reductions, cycle shortenings, and power plant closures were considered by utilities. In addition, Siemens considered contingency plans to shift fuel fabrication to other sites and fabricators. Nevertheless, Siemens has confidence in the Hanau uranium works and plans investments of more than US$386 million in expansions.

The ageing, 30 tonnes-per-year plutonium processing works for MOX fuel at SBH has been closed since June 18, 1991, following a contamination incident and several other serious incidents, including distorted lids on storage containers, inflated plastic covers around stored plutonium, and non-tested hydrogen gas lines. Meanwhile, construction of a new 120 tonnes-per-year MOX facility, in which Siemens is investing US$166 million, may be halted because of missing licensing documents. Consequently, licensing of MOX fuel for some reactors has been halted.

In April, the nuclear fuel production facility of Franco-Belge de Fabrication de Combustibles (FBFC) at Pierrelatte, France, was shut down due to unreported potential criticality conditions. The incidents involved incorrect storage and handling of nuclear material. FBFC had to improve operating procedures and personnel education prior to reopening.

The nature, magnitude, and number of incidents in 1991 are unusual for the fuel fabrication industry and have focused the attention of regulatory agencies on all industry participants.

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SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT

Several important developments occurred in 1991 in the areas of spent fuel and radioactive waste management. The issue of how to dispose of low-level waste (LLW) emerged as a major problem for US nuclear utilities and fuel cycle facilities as well as other LLW generators, such as hospitals and universities. As of January 1, 1993, the federal LLW disposal facilities at Beatty, Nevada; Barnwell, South Carolina; and Hanford, Washington, currently serving all LLW generators in the USA, will be closed or severely restricted to receipt of LLW. Since individual states are not required by federal law to take ownership and possession of LLW generated within their borders until 1996, LLW generators are caught in the middle, and will be responsible for storing their own waste. In addition, numerous uncertainties exist, including which rules LLW generators must follow, which licenses they must obtain, and whether the states will be ready in 1996. Furthermore, the constitutionality of the federal government's requiring the states to take on LLW responsibilities is being examined by the US Supreme Court. More challenges lie ahead, for distributed, rather than centralized LLW storage will result in siting controversies. Costs for existing storage will increase, investments in new facilities will be made, and these costs will be passed on to consumers.

US Nuclear Waste Negotiator David Leroy made notable progress in 1991, obtaining eight applications for grants to study the effects of hosting a Monitored Retrievable Storage (MRS) facility for high-level waste (HLW) and spent fuel. Five Indian tribes, two counties and one state applied for DOE Phase I grants of US$100 thousand each. Applying for the grants indicates only that the applicants are willing to study the topic; it creates no obligation to host an MRS, nor is there any assurance an applicant would be successful in obtaining an MRS. Phase II grants of up to US$3 million are being offered to study specific sites, negotiate with DOE for compensation, and establish some voice in facility operations. Although some groups are considering Phase II applications, none had made such a request by year end.

An encouraging milestone in HLW and spent fuel disposal activities in the USA occurred in July 1991 when the Yucca Mountain characterization project obtained access to the site and began trenching and drilling for test purposes. This access is a major step forward in the site characterization process, particularly after the many frustrating delays in the past, including deliberate blocking by the state of Nevada. Partially as a result of these delays and management shortfalls, DOE appointed a task force to conduct a one-year study on how DOE can restore public trust in the HLW program. To date, no country has a licensed, deep-geological repository for spent fuel or high-level waste, although most countries are studying the topic and some have test facilities. A solution to final disposal of spent fuel and HLW in the USA is crucial to the continued viability of the US nuclear power industry.

A major change in Europe began in 1991 when the United Kingdom (UK) began rethinking its longtime choice of reprocessing, and began to consider storage of spent fuel. As an example of the modified attitude, the chairman of Nuclear Electric announced he was not a supporter of reprocessing, if it were more expensive. Selecting the lower-cost option, Nuclear Electric signed one of the largest contracts in history (US$22 billion) with British Nuclear Fuels plc for fuel supply and reprocessing. Scottish Nuclear went even further in reversing its attitude toward reprocessing and selected dry storage of spent fuel for its advanced gas-cooled reactors.

Other 1991 events of note occurred in nuclear fuel reprocessing and recycling. The former Soviet Union decided to suspend work on a new 1,500 metric ton-per-year reprocessing plant for VVER-1000 fuel in Siberia. This action increases the pressure on Russia as well as its former east European customers, to provide for interim storage and final disposal of spent fuel. It also demands additional resources from utilities that are already struggling with issues of finance and safety.

Although the costs of fabricating mixed oxide (MOX) fuel are three to four times greater than conventional uranium fuel and few facilities exist, France, Germany, and Japan continued to support programs to recycle plutonium in

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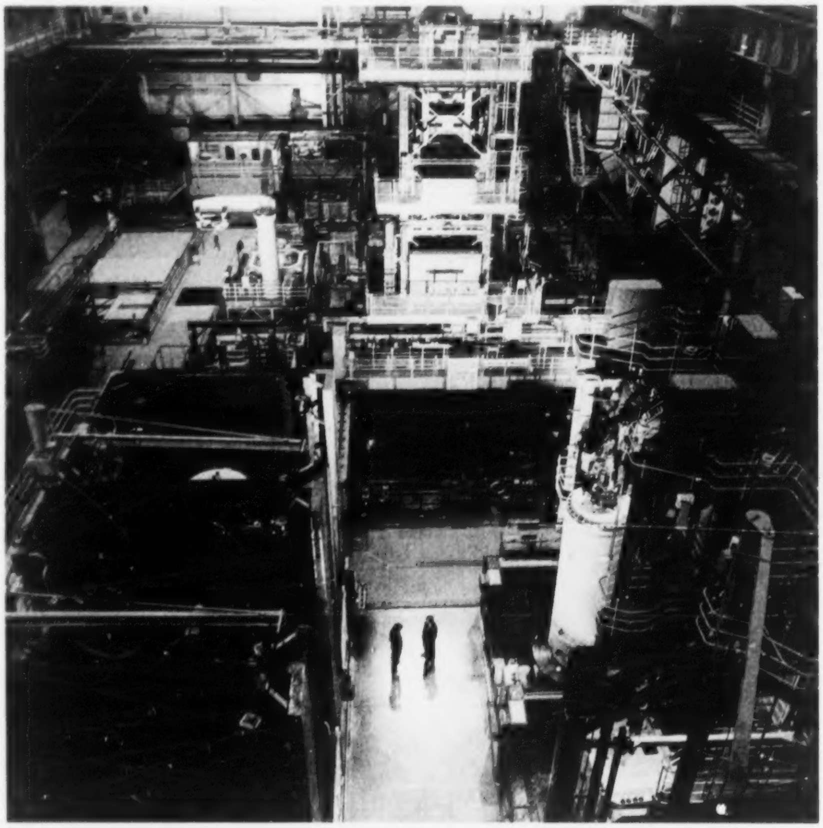

Figure 14 — THORP Reprocessing Plant. The receiving and storage facility at BNFL's thermal oxide reprocessing plant. *(Photo courtesy of BNFL)*

MOX fuel and breeder reactors by adding to their MOX fabrication capabilities and participating in fast breeder reactor studies. Support for MOX and plutonium utilization are clearly not motivated by economics, but come from reasons such as the inertia of past decisions, lack of sufficient storage and disposal capacity, and the abundance of plutonium.

Japan made significant progress in 1991 in planning, licensing, and constructing facilities for the storage of LLW, HLW, and spent fuel, and the reprocessing of spent fuel at Rokkashomura. When these facilities are completed, Japanese spent fuel, formerly sent to France for reprocessing, will be stored and reprocessed domestically. While this represents a further diversification of reprocessing capability, it also represents a capacity addition to an already over-supplied nuclear fuel market.

In some countries, final disposal of spent fuel with no intervening reprocessing, has been the choice for years; in others, the decision to eliminate the reprocessing step has come more recently. In still others, reprocessing continues to be used, in part because of insufficient storage and disposal capacity. In every situation, the problem to be addressed is where and how to dispose of the toxic materials, and solving this problem is vital for the viability of nuclear industries in every part of the world. Consequently, the nuclear industry in each country is striving to find suitable sites and adequate funding to develop facilities.

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GABON

Uranium production in Gabon fell 16 percent in 1991, to 1.55 million pounds equivalent U_3O_8. Compared to 1990 levels, production dropped nearly 300 thousand pounds, which can be attributed partly to lower ore grade and reduced demand, but primarily to the closing of the Boyindzi mine. Output for 1992 is expected to remain nearly equivalent to 1991 levels.

The Mounana uranium production center has an annual production capacity of 4.2 million pounds equivalent U_3O_8 and is operated by Compagnie des Mines d'Uranium de Franceville (Comuf). Seventy-five percent of Comuf is owned by a consortium of French-owned entities and 25 percent is owned by the Gabonese government (**Table 14**).

Uranium output from the Mounana mill, located in the Haut-Ogooue region of eastern Gabon, is exported by way of the terminal at Owendo near Gabon's capital of Libreville. The ore for the mill is provided by two mines, Okelobondo and Boyindzi. The Okelobondo underground mine exploits the Oklo deposit, which was first mined as an open-pit deposit from 1970 to 1985, and subsequently mined using underground methods. Oklo had initial reserves of 58 million pounds U_3O_8 at an average grade of 0.42 °/o U_3O_8. The Boyindzi deposit, exploited by the mine of the same name, was developed for underground mining in 1970. Its initial reserves were estimated at over 8 million pounds U_3O_8 with an average grade of 0.29 percent U_3O_8. Production at this mine continued through early 1991, when it was closed by Comuf due to cost-cutting measures. The closing of the mine was a primary reason for the decline in total Mounana production in 1991.

Table 14
COMUF OWNERSHIP

Gabon Government	24.8%
Compagnie Française de Mokta [1]	39.0%
Cogema	18.8%
Uranium Pechiney	10.6%
Cofirmer	5.8%
Gabonese Individuals	1.0%
Total	**100.0%**

[1] Wholly owned subsidiary of Cogema

Gabon's uranium is marketed by Cogema of France, who indirectly owns 57.8 percent of Comuf. Other shareholders of Comuf receive their pro-rata share of the consortium's returns via Cogema. At least 70 percent of Gabon's uranium in exported to France. Cogema is the major purchaser, who in turn, sells the large majority of the uranium to Electricité de France and the remainder to other nuclear utilities worldwide under long-term contracts. Gabon's uranium production costs substantially exceed current market prices, but higher-priced contracts essentially subsidize uranium production in Gabon. Although this former French colony does not rely upon uranium exports as its primary source of foreign exchange, the exports do make important contributions to domestic employment and the country's balance of payments, and provide France a continued avenue of influence in the country. Thus any decision to reduce the quantity or price of French uranium imports must take into account political as well as economic considerations.

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NAMIBIA

Production from Namibia's sole uranium operation, the Rössing project, dropped significantly in 1991. Output fell 24 percent, from 8.35 million pounds to 6.37 million pounds equivalent U_3O_8, Rössing's lowest production level since 1977. In April 1991, Rössing Uranium Ltd. (RUL), the owner and operator of the project, announced that production levels were cut 21 percent to an annual rate of 6.5 million pounds. In September, RUL made further cuts to a five million pound annual production rate. RUL has undertaken many cost-cutting measures in an effort to continue production until the currently depressed uranium market recovers. The new production levels reflect the expiration in the last two years of several long-term contracts with utilities in Japan. RUL still has several other long-term contracts worldwide and also signed new contracts with Total Compagnie Minière for deliveries to Electricité de France in late 1990 and with Gulf States Utilities of the USA in March 1991.

Namibia became independent on March 21, 1990. The country is depending on Rössing for its economic health, for over recent years, RUL has produced one-third of the nation's exports, and accounted for 13 percent of its domestic product. The project (**Figure 15**) is one of the largest uranium mines in the world, an open-pit mine that has produced over 120 million pounds equivalent U_3O_8 from 1976 through 1991, and still holds well over 300 million pounds U_3O_8 in reserves.

Several companies have major ownership interests in RUL; the largest share is owned by the RTZ Corporation of the UK (**Table 15**). The Namibian government technically only owns 3.5 percent of RUL through a trust, but has a 51-percent voting interest in the operation, thereby technically having controlling rights as to how the project is operated. RTZ manages the operation and handles the marketing and sales of all uranium produced at Rössing.

Figure 15 — Rössing Uranium Ltd.'s Processing Plant.
(Photo courtesy of RTZ.)

Table 15
OWNERSHIP OF
RÖSSING URANIUM LIMITED

Company	Country	Share
The RTZ Corporation plc [1]	UK	41.3%
Industrial Development Corp.	South Africa	10.0%
Total Compagnie Miniére	France	10.0%
Rio Algom Ltd. [1]	Canada	10.0%
Urangesellschaft mbH [2]	Germany	5.0%
Capricorn Trust [3]	Namibia	3.5%
General Mining Corp.	South Africa	2.3%
Undisclosed [4]	———	17.9%

[1] RTZ owns 51.5 percent of Rio Algom, so RTZ's net beneficial interest in Rössing is 46.5 percent.

[2] Cogema is in the process of purchasing a controlling interest in Urangesellschaft.

[3] The Capricorn Trust was established in 1987 to hold and manage Namibia's share in Rössing. Dividend income is used for educational and other benefits for Namibia's people.

[4] 17.9 percent is held by several companies or national entities (including Iranian interests) that have not been widely disclosed.

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NIGER

Uranium is Niger's leading commodity, accounting for over one-third of the country's export earnings and contributing almost one-eighth of the national budget. Uranium production from Niger declined 20 percent in 1991, falling to 5.9 million pounds equivalent U_3O_8. This 1.5 million pound decline is due to dramatic cost-cutting measures implemented by Cominak and Somair, the two uranium consortiums that own Niger's major uranium projects. The cost-saving measures reduced staff by twenty percent and were made in an effort to improve productivity and bring actual production closer to contracted delivery requirements.

Niger has two major uranium projects: Akouta and Arlit. Akouta is the world's largest underground mine and is owned by Compagnie Miniere d'Akouta (Cominak), a consortium comprised of Cogema; Onarem (Office Nationale des Resources Minieres), the state-owned mineral resources company of Niger; Japan's Overseas Uranium Resources Development Company (OURD); and ENUSA, the Spanish fuel-cycle company (**Table 16**). The Akouta facility produced about 3.9 million pounds in 1991. Approximately half of the production is exported by Cogema, with the balance going to Spanish and Japanese interests.

Table 16
COMINAK OWNERSHIP

Cogema (France)	34%
Onarem (Niger)	31%
Overseas Uranium Resources Development Company (Japan)	25%
ENUSA (Spain)	10%
Total	**100%**

The Arlit project is located only about 10 kilometers from the Akouta project in north-central Niger, near the southern edge of the Sahara Desert. Arlit is a series of open-pit mines owned by Societé des Mines de L'Air (Somair) and operated by Cogema. Somair's ownership is shown in **Table 17**. Production began at the three Arlit deposits (Arlette, Ariege, Artois) in 1971 and shifted to the nearby Taza deposit in 1988, because this deposit offered a lower stripping ratio and higher grade ore. The Somair uranium mill has a design capacity of 6.5 million pounds U_3O_8 per year. It utilizes conventional milling for higher-grade ores (greater than 0.18 weight-percent U_3O_8) and heap leaching for lower-grade ores (from 0.18 to 0.08 weight-percent U_3O_8).

Table 17
SOMAIR OWNERSHIP

Onarem (Niger)	33.0%
Cogema (France)	27.0%
Compagnie Française de Mokta[1] (France)	19.4%
Uranium Pechiney (France)	7.6%
Urangesellschaft mbH (Germany)	6.5%
Agip SpA (Italy)	6.5%
Total	**100.0%**

[1] Wholly owned subsidiary of Cogema

In 1991, Arlit production equaled two million pounds equivalent U_3O_8, the majority of which is marketed by Cogema and Onarem. Given the country's dependence on uranium exports, purchases by France at above-market prices is vital to the economic outlook of Niger. Thus, like Gabon, political and economic factors must be considered before any change in French uranium purchasing policy can be made that would affect this former French colony.

As illustrated in the ownership tables, the government of Niger owns shares in all the country's uranium resources through Onarem. Onarem was established in 1976 to coordinate and participate in all uranium exploration and development in the country, and is required by law to be a partner in all uranium ventures.

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SOUTH AFRICA

URANIUM PRODUCTION

For the eighth consecutive year, uranium production in South Africa declined significantly. In 1991, total production dropped 33 percent from its 1990 level, falling to 4.3 million pounds equivalent U_3O_8 (**Table 18**). During the year, dramatic progress was made toward the abolishment of apartheid, and as a result most countries lifted their economic sanctions against South Africa. However, this had minimal effect on the sale of South African origin uranium on the world market, and on the country's production levels in 1991. Even in 1992, with South African origin uranium once again acceptable in world markets, uranium production is unlikely to increase. All uranium produced in South Africa is recovered as a by-product of gold ore processing, except at Palabora, where uranium is recovered as a by-product of copper mining. Thus, uranium production levels have declined primarily as a result of the currently depressed market prices for both gold and uranium.

Of the 2.1 million pound decrease for the year, over 570 thousand pounds (27 percent) can be attributed to the shutdown of Freegold (formerly the Free State Joint Metallurgical Scheme) and the East Rand Gold and Uranium Company (ERGO). Buffelsfontein production declined 291 thousand pounds from its 1990 level. The company announced in the third quarter that it would cease uranium production as soon as possible, and did so early in the fourth quarter. Hartebeestfontein also produced at lower levels throughout the year; its total was down 20 percent, to 579 thousand pounds. Production cuts at Vaal Reefs, South Africa's largest uranium producer, accounted for most of the remaining decrease. In the fourth quarter of 1990, Vaal Reefs announced that production at its west uranium plant was being cut by 50 percent and that production at its east plant had been suspended until market conditions improved. As a result, Vaal Reefs' 1991 production declined by 1.1 million pounds (54 percent of the total 1991 decrease), to 2.4 million pounds equivalent U_3O_8.

Of all of the uranium-producing members of South Africa's Chamber of Mines, only Western Areas showed an increase in production climbing ten percent in 1991, to 639 thousand pounds. The augmented output was the result of improved ore grade. Palabora Mining Company (**Figure 16**) produced an estimated 200 thousand pounds U_3O_8, down from its 1990 level of 241 thousand pounds.

Table 18
SOUTH AFRICAN URANIUM PRODUCTION BY MINE (1990-1991)

MINE	1990	1991	Percent Change[1]
Operating:			
Buffelsfontein	699	408	- 41.6
Hartebeestfontein	725	579	- 20.1
Vaal Reefs	3,575	2,434	- 31.9
Western Areas	579	639	+10.4
Palabora	241	200	- 17.0
Closed:			
ERGO[2]	213	8	- 96.2
Freegold[3]	368	0	- 100.0
Total[4]	**6,400**	**4,269**	**- 33.3**

[1] Change in percent from the 1990 total.
[2] ERGO = East Rand Gold and Uranium Company Ltd.
[3] Formerly Free State Joint Metallurgical Scheme.
[4] Columns may not add up due to independent rounding.

NUCLEAR POWER PROGRAM

South Africa's sole nuclear power station, Koeberg, is located at Melkbosstrand about 30 km from Cape Town. The station is owned and operated by ESKOM, the national utility, and contains two 920-MWe PWRs, which account for about five percent of the country's installed generating capacity. In 1991, the two reactors combined to produce 9,243 GWh at an average capacity factor of 57 percent (**Table 19**). This quantity accounted for about six percent of South Africa's total electricity generation.

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AFRICA

Figure 16 — Aerial View of the Palabora Mine. The project produced an estimated 200 thousand pounds equivalent U_3O_8 in 1991 as a by-product of copper production. *(Photo courtesy of Palabora Mining Company)*

Due to the fact the country did not sign the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) until 1991, South Africa was forced to develop its fuel cycle domestically. The Atomic Energy Corporation of South Africa Ltd. (AEC) operates a commercial helikon uranium enrichment plant at Pelindaba East (formerly known as Valindaba). The plant, first declared commercial this past year, has an annual capacity of 300 thousand SWU, which is more than sufficient to meet Koeberg's requirements.

The AEC announced in early 1992 that it plans to test a prototype molecular laser isotope separation (MLIS) enrichment unit by 1997. The tests will examine the economic and technical parameters of an MLIS plant, which uses lasers to excite molecules, rather than individual uranium atoms as in the AVLIS process under development in the USA and France. South Africa also had been pursuing research efforts on centrifuge enrichment, but has ceased these efforts and will focus on MLIS development.

The AEC also is responsible for a fuel fabrication plant at Pelindaba West. The facility has a capacity of 100 MTU per year, but currently is producing only 20 MTU annually. Construction on the plant began in 1980, with the first assemblies delivered in 1988. Through 1991, the plant has provided three reloads to the Koeberg station.

South Africa's national radioactive waste disposal site located at Vaalputs began accepting low- and intermediate-level waste in 1986. Spent fuel from the Koeberg reactors is not yet sent to Vaalputs, but is stored in high density racks at the station. There is

Table 19
NUCLEAR POWER UNITS IN SOUTH AFRICA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Koeberg 1	ESKOM	920	PWR	1984	74	5,984
Koeberg 2	ESKOM	920	PWR	1985	40	3,259
TOTAL		**1,840**		*(1991 Average:*	**57)**	**9,243**

[1] COD = Commercial Operation Date

sufficient capacity at Koeberg to store the fuel through 1998, the date that Vaalputs is expected to have the capability to store the spent fuel.

In a very significant step toward integration into the world's nuclear community, South Africa signed the NPT on July 10, 1991. The country also rapidly concluded an IAEA safeguards agreement, signing in about two months an agreement normally negotiated in 1 to 1 1/2 years. These agreements, combined with the lifting of economic sanctions, have allowed the country to once again buy and sell nuclear-related products and services, and openly participate in the exchange of nuclear-related information.

POLITICAL DEVELOPMENTS

The year 1991 was historic for South Africa, as major steps were taken to advance social and political reform. The progress resulted in the lifting of economic sanctions by most countries. The advancements led to a dramatic vote on March 17, 1992. In this whites-only election, 69 percent of voters chose to support South African President F.W. de Klerk's reforms and to back continued negotiations for a new non-racial constitution for the country.

One of the most evident steps taken by De Klerk during 1991, was his February 1 announcement that the Land Acts and Group Areas Act had been repealed, and his promise that the Population Registration Act would be phased out. The Group Areas Act segregated black and white residential areas, and the Land Acts barred blacks from owning land outside specially designated areas. The Population Registration Act, the most controversial of laws, forced South Africans to register by racial group for economic and political purposes. On June 17, this Act which formed the legal foundation for apartheid, was officially repealed by the South African Parliament.

Another major development during the year was the formation of Codesa (Convention for a Democratic South Africa). The group was formed to develop a new, non-racial constitution for the country. Codesa is comprised of nineteen different parties; membership is limited to political parties only. It held its first multi-party conference near the end of December 1991, and has since divided into five working groups each concentrating on specific issues. Most of the major constituency groups are represented in the convention, including De Klerk's ruling National Party (NP), the African National Congress (ANC), the liberal Democratic Party, and the Inkatha Freedom Party. The right-wing Conservative Party as well as far-right wing and far-left wing parties such as the Pan African Congress were invited to participate in the talks, but have refused. The next complete meeting of Codesa is scheduled for April.

A variety of schedules for the transition of the South African government have been proposed. The timetables submitted by the NP and the ANC are quite similar, each calling for an interim government by June 1992, an elected constituent assembly by the second quarter of 1993, and a finalized constitution by early 1994.

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ASIA

South Korea
Japan
China
Pakistan
Taiwan
India
Philippines
Thailand
Indonesia

CHINA

This past year proved to be notable in China's nuclear power program, as several important events occurred within the year. The startup of China's first commercial reactor, indications that the country will sign the Treaty on the Non-Proliferation of Nuclear Weapons, and the reaffirmation of ambitious domestic nuclear power plans all figured prominently in 1991.

The People's Republic of China is projecting enormous energy demand (1.2 billion MWh) by the year 2000. Thus, China is moving forward with plans to have 6,000 MWe of nuclear-generating capacity installed by the end of this decade, and to have another 6,000 MWe under construction for completion after the turn of the century. The new units will not only provide much needed energy, but also will help to alleviate China's strong reliance on coal-based generation.

NUCLEAR POWER PROGRAM

Qinshan

The recent startup of China's first commercial nuclear reactor at the Qinshan facility south of Shanghai marked a major milestone in China's nuclear power program. The unit, a 300-MWe pressurized water reactor of indigenous design, attained criticality on December 15, 1991.

Additional plans for the Qinshan site were revealed by China National Nuclear Corporation (CNNC) President Jiang Xinxiong in January 1991. He announced that China is planning to add a second, matching 300-MWe unit, as well as two newly-designed 600-MWe units to the Qinshan station. The conceptual design for the 600-MWe units has been approved, and construction is expected to begin during the first half of the decade.

Daya Bay

Two 900-MWe PWRs are currently under construction at the Daya Bay nuclear power facility in Guangdong province in southern China (**Table 20**). The design and equipment for these two plants are being provided by the European companies of Framatome and GEC Alsthom, with technical supervision by Electricité de France. The units are currently scheduled for operation in 1993 and 1994, respectively. CNNC President Jiang disclosed that two additional units also are under consideration for that location.

OTHER EVENTS

During a summit with former Japanese Prime Minister Toshiki Kaifu in Beijing last August, Chinese Premier Li Peng expressed China's willingness "in-principle" to sign the Treaty on the Non-Proliferation of Nuclear Weapons.

Table 20
NUCLEAR POWER UNITS IN THE PEOPLE'S REPUBLIC OF CHINA

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	Percent Complete [2]
Qinshan 1	CNEIC [3]	300	PWR	1992	100
Daya Bay 1	CNEIC	910	PWR	1993	70
Daya Bay 2	CNEIC	910	PWR	1994	60
TOTAL		**2,120**			

[1] COD = Commercial Operation Date (expected)
[2] Source: *Nuclear News*
[3] CNEIC = China Nuclear Energy Industry Corporation

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The announcement made China the last of the world's five declared nuclear-weapon states to announce its intention to sign the document, and in early March 1992, China formally acceded to the treaty.

In December, China signed an agreement with Pakistan for the sale of a Chinese-designed 300-MWe nuclear power reactor to be built at Chashma. The accord, originally agreed to in 1989, was reported to have been settled at "friendship prices". The plant is scheduled for operation in approximately six years.

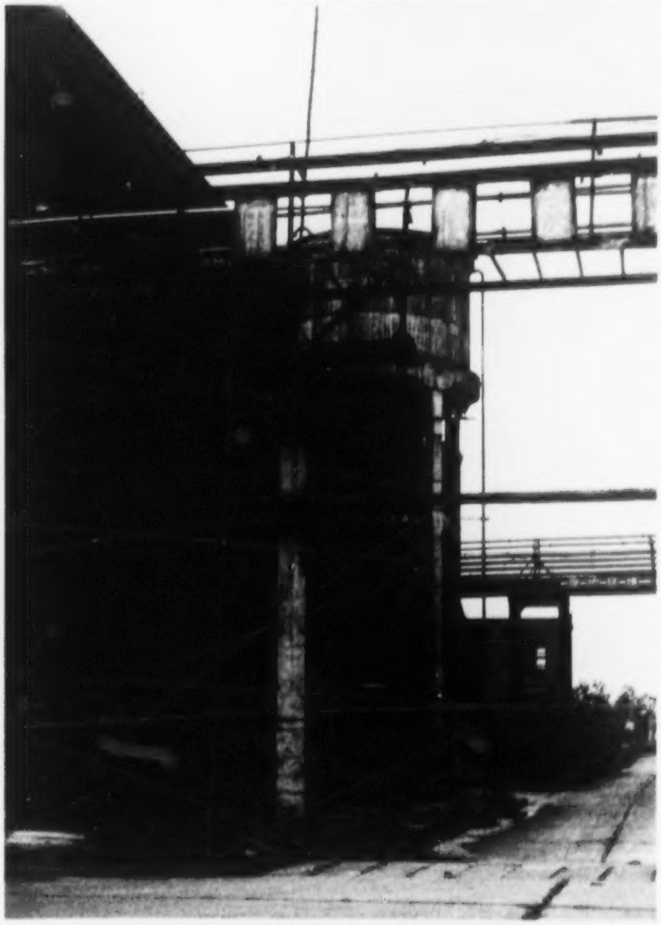

Figure 17 — Hengyang Uranium Mill. (*Photo courtesy of CNEIC*)

FUEL CYCLE FACILITIES

China has a well-developed uranium industry capable of supporting the nation's ambitious domestic nuclear program. China's reasonably assured resources, plus estimated additional resources, exceed 140 million pounds equivalent U_3O_8, which is distributed among five primary districts/deposits (**Figure 17**). Most of the country's numerous deposits are small and of low grade (0.05-0.25 % U_3O_8), but the combined production capability is substantial. China operates as many as nine uranium processing centers spread around the country; the two most important are the Hengyang mill in Hunan province and the Henjian mill in Jiangxi province. Estimates indicate that China is operating at about 50 percent of its total uranium production capability of ten million pounds equivalent U_3O_8 annually.

The country also operates an enrichment plant at Lanzhou in north-central China. The plant uses gaseous diffusion technology and was recently expanded. CNNC has indicated it can export up to 500 thousand SWU per year. At the Yibin fabrication facility, CNNC has the capability of processing up to 150 metric tons uranium for use as PWR fuel. In addition, China has plans for a reprocessing facility in the Gansu province and plans for a high-level waste storage facility in the Shanxi province.

INDIA

Financial considerations and delays resulted in the reduction of India's 1991 nuclear power generation projections. The Indian Atomic Energy Commission announced last August that total generation targets were reduced from 10,000 MWe to 9,000 MWe, and this figure may be revised even lower. India did bring on line two units in 1991: Narora 1 and 2, both 220-MWe pressurized heavy water reactors, located in the northern state of Uttar Pradesh (**Table 21**). Unit 1 was declared commercial on January 1, 1991. Narora 2, India's eighth reactor, attained criticality in December; it is expected to reach commercial operation in 1992.

Table 21
NUCLEAR POWER UNITS IN INDIA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Kalpakkam 1 (MAPS)	NPC [2]	175	PHWR	1984	36	552
Kalpakkam 2 (MAPS)	NPC	175	PHWR	1985	76	1,169
Narora 1 (NAPP)	NPC	220	PHWR	1991 [3]	28	545
Rajasthan 1 (RAPS)	NPC	207	PHWR	1973	12	226
Rajasthan 2 (RAPS)	NPC	207	PHWR	1981	51	933
Tarapur 1 (TAPS)	NPC	150	BWR	1969	61	806
Tarapur 2 (TAPS)	NPC	150	BWR	1969	67	874
TOTAL		**1,284**		*(1991 Average:*	**45)**	**5,105**

Units Under Construction and Planned

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	Percent Complete [4]
Kaiga 1	NPC	220	PHWR	1995	40
Kaiga 2	NPC	220	PHWR	1996	40
Kakrapar 1 (KAPP)	NPC	220	PHWR	1993	89
Kakrapar 2 (KAPP)	NPC	220	PHWR	1994	89
Narora 2 (NAPP)	NPC	220	PHWR	1992	100
Rajasthan 3	NPC	220	PHWR	1995	31
Rajasthan 4	NPC	220	PHWR	1996	31
Tarapur 3 (TAPS)	NPC	470	BWR	2000	planned
Tarapur 4 (TAPS)	NPC	470	BWR	2001	planned
TOTAL		**2,480**			

[1] COD = Commercial Operation Date (actual or expected)

[2] NPC = Nuclear Power Corporation (Department of Atomic Energy)

[3] Source: NPC—Contrary to other sources, NPC stated that Narora 1 was declared in commercial operation on January 1, 1991. As the plant operated effectively for the full year, a capacity factor is shown and its generation is included in calculation of the 1991 Average Capacity Factor.

[4] Source: *Nuclear News*

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The seven commercial units generated 5,105 GWh of electricity with an average capacity factor of 45 percent. Total installed nuclear capacity reached 1,284 MWe this past year from two BWRs and five PHWRs. In addition to Narora 2, six more PHWR-type units, all rated at 220 MWe, are expected to be completed within five years. These new units will be sited two each at Kaiga and Rajasthan in Karnataka state, and at Kakrapar in Gujarat state. The planned December 1991 startup for Kakrapar 1 has been pushed back after a fire in that units' switchyard.

The site for a proposed 4,000-megawatt station (eight 500-MWe units) has been selected by India's National Power Corporation. The plant, to be located at Kerala in the state of Trikkareppur, would be the largest facility of its kind in India. The units are to be constructed with assistance from Atomenergoexport of the former Soviet Union, although with the recent changes in that country, the timely construction of this station is increasingly uncertain.

Soviet Reactor Purchase

There are indications that a project to import two 1000-MWe VVER reactors from the former Soviet Union has been scuttled. The agreement was originally signed between the two countries in 1988. Plans called for construction of the facility, intended for Koodangulam in the southern state of Tamil Nadu, to begin in 1992 and reach completion before 2000. Recent reports from India's National Power Corporation in New Delhi suggest, however, that the plan is now off. Financing terms seemed to be the major subject of discord.

Nuclear Fuel Production

India maintains an active nuclear fuel production program, in accordance with its stated self-reliance policy. In 1991, India's Department of Atomic Energy published plans to invest over seven billion rupees (US$270 million) over the next ten years into nuclear fuel production. Plans are being considered to develop a recently discovered uranium deposit at Domiasat, in the state of Meghalaya. The sandstone-type deposit is the largest deposit ever discovered in the country, with grades as high as 0.41 % U_3O_8. Two new underground mines, located in Turamdih and Narwapahar, are under development by the Uranium Corporation of India Ltd. The country's expansion plans also include increasing the UO_2 pellet production capacity at its Hyderabad uranium oxide fuel plant from 350 MT-per-year to 660 MT per year; building a uranium fuel assembly plant, also at Hyderabad; and commissioning a 150 MT-per-year Zircaloy fabrication plant. The Department of Atomic Energy also is planning to build a 300 MT-per-year zirconium sponge plant near Palayakayal in Tamil Nadu state.

INDONESIA

Despite being a major world exporter of oil, Indonesia's rapid growth (five to six percent annually) has led the country's government to develop ambitious nuclear power plans. Indonesia's National Atomic Energy Agency (BATAN) has proposed construction of a dozen nuclear plants on the main island of Java. Bids are currently being sought for the first unit, a 600-MWe unit. Plans call for the unit to begin construction in 1996 and reach commercial operation in 2003. The remainder of the planned reactors will start up periodically through 2015, and will provide almost 7,000 MWe of additional generating capacity.

In a first step toward these goals, the Indonesian Minister of Finance and BATAN awarded a contract in August 1991 to New Japan Engineering Consultants, a subsidiary of Kansai Electric Power company, to conduct a site feasibility study. The study will build upon several previous feasibility studies and will analyze site selection, reactor type, safety procedures, and environmental effects. The $11.5 million study will be completed by the end of 1995.

Indonesia also has built a nuclear research complex at Serpong on Java, that includes a pilot-scale fuel fabrication plant and a waste processing center, as well as a 30-MWt research reactor. In addition, the country has identified approximately 25 million pounds equivalent U_3O_8 of uranium reserves in the Kalan area of West Kalimantan (Borneo), north of Java.

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JAPAN

The Japanese nuclear power industry made two new additions to its growing program during 1991: Tomari 2, a 550-MWe PWR owned and operated by Hokkaido Electric Power Company (**Figure 18**); and Ohi 3, a 1,121-MWe PWR owned and operated by Kansai Electric Power Company (**Figure 19**). The new plants push Japan's total number of nuclear power reactors to 42, with a combined net capacity of 31,981 MWe, which represents approximately 18 percent of Japan's total installed capacity. The industry's reactors continued to operate well, achieving an average capacity factor of 73 percent for the year and generating almost 200 TWh of electricity (**Table 23**), more than 26 percent of all power generated in Japan in 1991. Japan's reactors now have averaged better than 70 percent capacity factor for ten consecutive years.

Construction continued on ten power plants, although no new projects were announced during the year. Tokyo Electric Power Corporation (TEPCO) broke ground on construction of Kashiwazaki-Kariwa units 6 and 7 in September. Both of these reactors will be General Electric-designed advanced boiling water reactors. While two new units have come on-line in both 1990 and 1991, based on current completion schedules, no new reactors are expected to be connected to the grid until 1993. That year, four plants are scheduled to be added: Hamaoka 4, Kashiwazaki-Kariwa 3, Ohi 4, and Shika 1.

Figure 18 — Tomari Nuclear Power Station. Owned and operated by Hokkaido Electric Power Company, Unit 2, a 550-MWe PWR, was one of Japan's two units to enter commercial operation in 1991. (*Photo courtesy of Hokkaido EPC*)

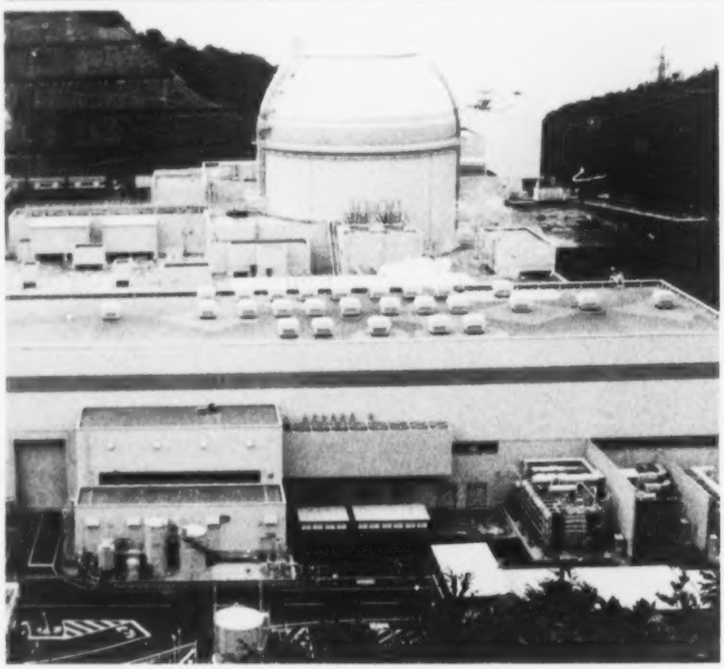

Figure 19 — Ohi 3, 1,121-MWe PWR. Owned and operated by Kansai EPC, it also entered commercial operation in 1991. *(Photo courtesy of Kansai EPC)*

Overall, 1991 was a significant year for the Japanese nuclear industry for a number of reasons. The year began with the crucial and closely followed elections in Aomori prefecture and Aomori city, as two anti-nuclear candidates entered the prefecture's gubernatorial race vowing to freeze or kill the Rokkashomura fuel-cycle project if elected. The incumbent, Mr. Kitamura, drew upon his pro-nuclear and pro-development constituency, the nuclear power industry, and the Liberal Democratic Party to win the election and ensure the continuation of the project.

Nuclear industry planners and utilities were very concerned over the possible postponement of projects being developed at Rokkashomura, since the complex was designed to give Japan capabilities in several areas and essentially complete the country's fuel cycle. If the complex were delayed, many future plans regarding enrichment, reprocessing, and high-level waste storage would have had to be reconsidered.

Less than a week after the Aomori elections, Japan experienced its worst nuclear mishap ever. A tube in the steam generator at Mihama 2 (470-MWe PWR) ruptured, and led to the automatic activation of the emergency core cooling system. Although the severity of the February 9 incident was minor in terms of international rating systems, it lowered public confidence in the Japanese nuclear industry. The Ministry of International Trade and Industry (MITI) launched an extensive investigation to determine the reason and responsibility for the incident, found to be caused by improper installation of anti-vibration bars. Following the event, an inspection of all PWR power stations in Japan was conducted to identify any potential problems at other stations. The few isolated instances of improper anti-vibration bar installation discovered during the follow up inspections were quickly corrected. Due to the incident, Mihama 2 was shut down and will remain down for further studies until its steam generator is replaced in 1995. Overall, Japan's safety and operation record remains one of the best in the world, and the Mihama 2 incident has served to further Japan's commitment to that end.

Table 22
JAPANESE ANNUAL ADDITIONS OF NUCLEAR GENERATING CAPACITY 1966-1991

Year	Capacity Addition (Gross MWe)	Total MWe at Year End
1966-1979	—	15,117
1980	0	15,117
1981	559	15,676
1982	1,666	17,342
1983	0	17,342
1984	2,514	19,856
1985	4,830	24,686
1986	0	24,686
1987	3,360	28,046
1988	0	28,046
1989	1,399	28,251
1990	2,200	31,645
1991	1,754	33,399

FUEL CYCLE DEVELOPMENTS

Japan continued to make progress at its Rokkashomura fuel cycle complex on the northern end of Honshu Island (**Figure 20**). During 1991, the facility's enrichment plant received its first UF_6 shipments and began initial test production. The centrifuge enrichment plant currently has a 150 thousand SWU-per-year capacity, that will be expanded to a total annual capacity of 1.5 million SWU by the year 2000. Plans for a second plant at the site of the same capacity have been developed as well. When the two plants are complete, Japan expects to have the capability to produce up to 3 million SWU per year, or about 40 percent of the country's forecast domestic requirements.

When completed, the Rokkashomura complex also will contain several facilities related to the back end of the fuel cycle. Construction on the 800 metric-ton-per-year reprocessing center is scheduled to begin the end of 1992, with test operations expected to start in 1999. Progress continued on the fuel-cycle complex's low-level waste facility that will have a capacity of 200 thousand cubic meters. A temporary storage facility for high-level waste is planned to begin accepting material in 1995.

Two significant developments in the fuel procurement area occurred in 1991. At least 15 new long-term contracts were concluded by Japanese utilities, totalling more than 14 million pounds equivalent U_3O_8. Secondly, and perhaps more notable, was the decision by some utilities to utilize the secondary uranium market. This action was viewed by many as a welcome sign of Japan's integration into the secondary market, since it was the last of the major commercial nuclear countries to participate in this market.

FUTURE PLANS

Once the Gulf War drew to a close, Japan was able to return to a degree of normalcy in its procurement of oil. However, the war's interruption of supplies further reinforced Japan's desire to reduce its dependence on oil and focus even more on energy supply diversification and conservation. Since the 1973 oil embargo when oil imports equaled 77 percent of its total primary energy needs, Japan has made great improvements in reducing its petroleum consumption. Today that figure is less than 60 percent and is expected to be 45 percent within 20 years. In order to accomplish this, MITI has emphasized nuclear power, saying it should be developed "to the greatest extent possible." In its most recent long-term plan, the government announced its intent to more than double installed nuclear capacity, to 72,500 MWe (gross) by 2010; however, the plants under construction and those with plans already approved total only about 25 percent of the additions needed to meet this aggressive goal.

The long-term goal of doubling capacity obviously will require numerous additional stations. This requirement poses the primary obstacle to the plan's completion, since Japan has few available sites on which to put new nuclear power stations. Consequently, many of the new plants are expected to be additional units at existing sites. For example, TEPCO's two new advanced boiling water reactors are being built on the existing Kashiwazaki-Kariwa site. Some new site proposals have been made within the industry and government, but nothing has been made public.

Education remains at the core of the country's long-term plan to develop its entire nuclear industry. To further industry objectives, great effort is being made to educate the public about the advantages and safety of commercial nuclear power, and the benefits of a supporting domestic fuel cycle industry. The new public relations center at the Rokkashomura fuel cycle facility is a prime example of this effort. Educational programs are being conducted not only with the local farmers and fishermen, but with the urban population as well. Through these grass-root approaches, Japan is hoping to gain public support and a greater understanding of the industry's long-term plans.

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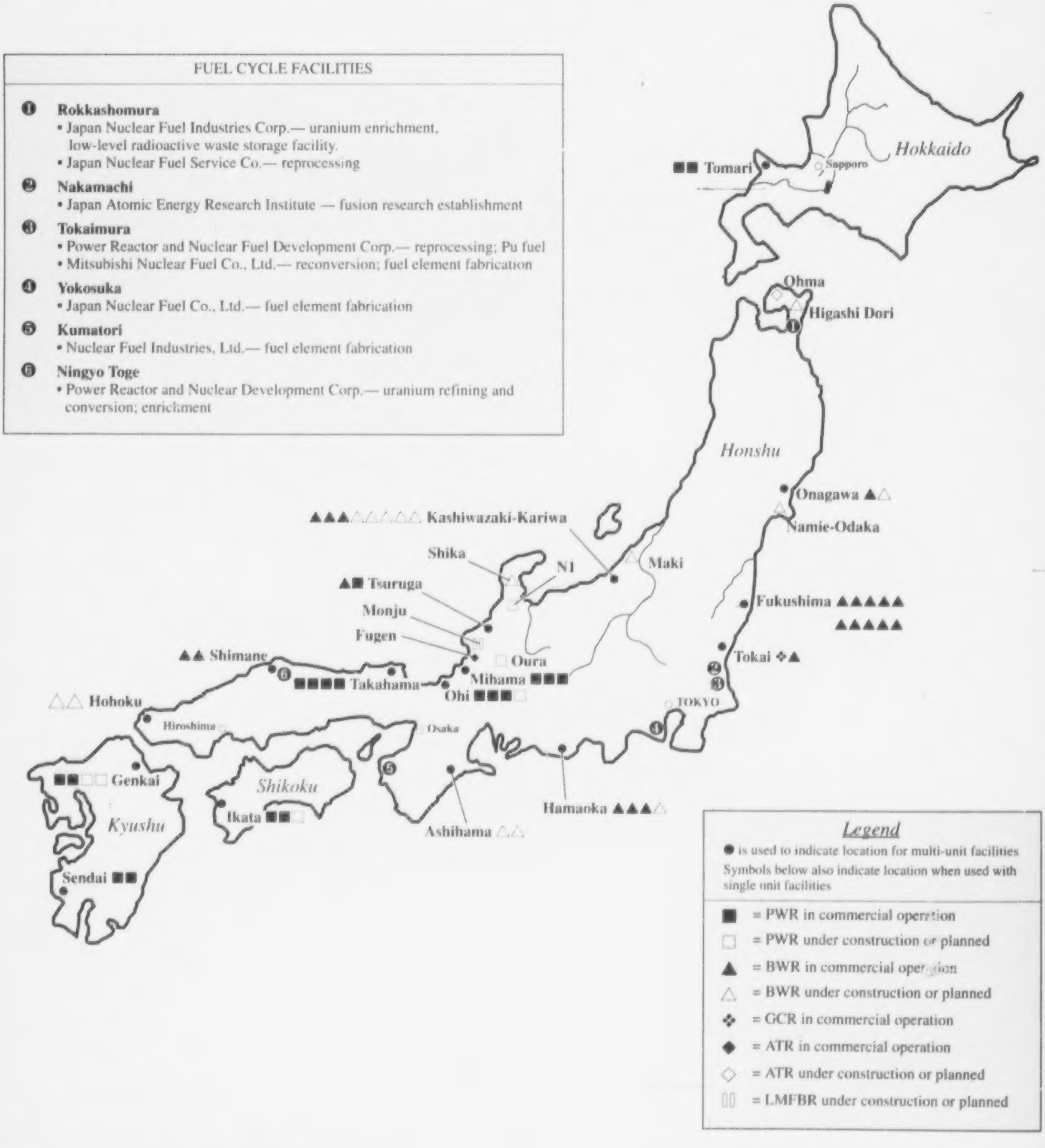
Figure 20
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES IN JAPAN



FUEL CYCLE FACILITIES

❶ **Rokkashomura**
- Japan Nuclear Fuel Industries Corp.— uranium enrichment, low-level radioactive waste storage facility.
- Japan Nuclear Fuel Service Co.— reprocessing

❷ **Nakamachi**
- Japan Atomic Energy Research Institute — fusion research establishment

❸ **Tokaimura**
- Power Reactor and Nuclear Fuel Development Corp.— reprocessing; Pu fuel
- Mitsubishi Nuclear Fuel Co., Ltd.— reconversion; fuel element fabrication

❹ **Yokosuka**
- Japan Nuclear Fuel Co., Ltd.— fuel element fabrication

❺ **Kumatori**
- Nuclear Fuel Industries, Ltd.— fuel element fabrication

❻ **Ningyo Toge**
- Power Reactor and Nuclear Development Corp.— uranium refining and conversion; enrichment

Legend

● is used to indicate location for multi-unit facilities
Symbols below also indicate location when used with single unit facilities

■ = PWR in commercial operation
□ = PWR under construction or planned
▲ = BWR in commercial operation
△ = BWR under construction or planned
❖ = GCR in commercial operation
◆ = ATR in commercial operation
◇ = ATR under construction or planned
▯▯ = LMFBR under construction or planned

Table 23
NUCLEAR POWER UNITS IN JAPAN

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Fugen	PNC[2]	148	ATR	1979	52	679
Fukushima I-1	Tokyo EPC[3]	439	BWR	1971	34	1,305
Fukushima I-2	Tokyo EPC	760	BWR	1974	59	3,896
Fukushima I-3	Tokyo EPC	760	BWR	1976	68	4,497
Fukushima I-4	Tokyo EPC	760	BWR	1978	97	6,462
Fukushima I-5	Tokyo EPC	760	BWR	1978	99	6,591
Fukushima I-6	Tokyo EPC	1,067	BWR	1979	74	6,945
Fukushima II-1	Tokyo EPC	1,067	BWR	1982	67	6,243
Fukushima II-2	Tokyo EPC	1,067	BWR	1984	74	6,892
Fukushima II-3	Tokyo EPC	1,067	BWR	1985	83	7,744
Fukushima II-4	Tokyo EPC	1,067	BWR	1987	78	7,297
Genkai 1	Kyushu EPC	529	PWR	1975	73	3,371
Genkai 2	Kyushu EPC	529	PWR	1981	80	3,730
Hamaoka 1	Chubu EPC	515	BWR	1976	49	2,200
Hamaoka 2	Chubu EPC	806	BWR	1978	75	5,295
Hamaoka 3	Chubu EPC	1,066	BWR	1987	73	6,825
Ikata 1	Shikoku EPC	538	PWR	1977	93	4,397
Ikata 2	Shikoku EPC	538	PWR	1982	75	3,545
Kashiwazaki-Kariwa 1	Tokyo EPC	1,067	BWR	1985	97	9,087
Kashiwazaki-Kariwa 2	Tokyo EPC	1,045	BWR	1990	72	6,716
Kashiwazaki-Kariwa 5	Tokyo EPC	1,045	BWR	1990	76	7,134
Mihama 1	Kansai EPC	320	PWR	1970	86	2,402
Mihama 2	Kansai EPC	470	PWR	1972	11	451
Mihama 3	Kansai EPC	780	PWR	1976	62	4,257
Ohi 1	Kansai EPC	1,120	PWR	1979	58	5,657
Ohi 2	Kansai EPC	1,120	PWR	1979	65	6,349
Ohi 3	Kansai EPC	1,121	PWR	1991	—	376
Onagawa 1	Tohoku EPC	497	BWR	1984	78	3,413
Sendai 1	Kyushu EPC	846	PWR	1984	75	5,536
Sendai 2	Kyushu EPC	846	PWR	1985	76	5,603
Shimane 1	Chugoku EPC	439	BWR	1974	82	3,146
Shimane 2	Chugoku EPC	791	BWR	1989	80	5,564
Takahama 1	Kansai EPC	780	PWR	1974	70	4,813
Takahama 2	Kansai EPC	780	PWR	1974	26	1,767
Takahama 3	Kansai EPC	830	PWR	1985	75	5,429
Takahama 4	Kansai EPC	830	PWR	1985	83	6,070

[1] COD = Commercial Operation Date

[2] PNC = Power Reactor and Nuclear Fuel Development Corporation

[3] EPC = Electric Power Company

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Table 23
NUCLEAR POWER UNITS IN JAPAN
(continued)

Units In Operation
(continued)

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Tokai 1 [2]	JAPC [3]	159	GCR	1966	65	900
Tokai 2	JAPC	1,056	BWR	1978	76	7,027
Tomari 1	Hokkaido EPC [4]	550	PWR	1989	74	3,546
Tomari 2	Hokkaido EPC	550	PWR	1991	—	2,621
Tsuruga 1	JAPC	341	BWR	1970	76	2,280
Tsuruga 2	JAPC	1,115	PWR	1987	93	9,112
TOTAL		**31,981**		*(1991 Average:*	**73)** [5]	**197,166**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	Percent Complete [6]
Genkai 3	Kyushu EPC	1,121	PWR	1994	70
Genkai 4	Kyushu EPC	1,121	PWR	1997	26
Hamaoka 4	Chubu EPC	1,045	BWR	1993	81
Ikata 3	Shikoku EPC	846	PWR	1995	60
Kashiwazaki-Kariwa 3	Tokyo EPC	1,045	BWR	1993	87
Kashiwazaki-Kariwa 4	Tokyo EPC	1,045	BWR	1994	63
Kashiwazaki-Kariwa 6	Tokyo EPC	1,311	BWR	1996	6
Kashiwazaki-Kariwa 7	Tokyo EPC	1,311	BWR	1997	0
Monju	PNC [7]	280	LMFBR	1993	98
Ohi 4	Kansai EPC	1,121	PWR	1993	90
Onagawa 2	Tohoku EPC	784	BWR	1995	34
Shika 1	Hokuriku EPC	513	BWR	1993	83
TOTAL		**11,543**			

[1] COD = Commercial Operation Date (actual or expected)

[2] Will be decommissioned after 1995.

[3] JAPC = Japan Atomic Power Company

[4] EPC = Electric Power Company

[5] Average does not include those units that entered commercial operation or were retired during 1991.

[6] Source: *Atoms In Japan*

[7] PNC = Power Reactor and Nuclear Fuel Development Corporation

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Table 23
NUCLEAR POWER UNITS IN JAPAN
(continued)

Units Planned

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]
Ashihama 1[2]	Chubu EPC[3]	1,045	BWR	1997
Ashihama 2[2]	Chubu EPC	1,045	BWR	1998
Higashi Dori 1[2]	Tohoku EPC	1,045	BWR	1999
Hohoku 1[2]	Chugoku EPC	1,045	BWR	1997
Hohoku 2[2]	Chugoku EPC	1,045	BWR	1999
Kashiwazaki-Kariwa 8	Tokyo EPC	1,311	BWR	Unspecified
Maki 1	Tohoku EPC	796	BWR	2000
Namie-Odaka[2]	Tohoku EPC	796	BWR	2003
N1[2]	Hokuriku EPC	1,100	PWR	2003
Ohma[2]	EPDC[4]	556	ATR	2000
Oura 1[2]	Kansai EPC	1,200	PWR	1996
TOTAL		**10,984**		

[1] COD = Commercial Operation Date (expected)
[2] No authorization for development planning.
[3] EPC = Electric Power Company
[4] EPDC = Electric Power Development Company

PAKISTAN

A report prepared by the Water and Power Development Authority, the largest of Pakistan's two utilities, indicates that Pakistan is facing chronic power shortages. The total generation capacity of the two national utilities equals only 6,465 MWe, while anticipated demand for 1992 exceeds 8,500 MWe. The power shortfall could reach an estimated 4,000 MWe by the end of the decade, and the government wants nuclear power stations to fill at least half the deficit.

To begin addressing its nuclear power needs, on December 31, 1991, the Pakistan Atomic Energy Commission (PAEC) signed an agreement to purchase a 300-MWe nuclear power plant from China, finalizing a pact tentatively reached in 1989. The PWR, planned for commercial operation in 1998, will be located at Chasma and be subject to IAEA safeguards.

Pakistan's only operating commercial reactor is the 137-MWe Karachi nuclear power plant (Kanupp). The CANDU-type, pressurized heavy water reactor began operation in 1972. The station's turbine monitoring system was successfully replaced in 1991, but due to several other major outages, the unit generated less than 6,000 MWh, with an average capacity factor of only 35 percent.

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After successfully upgrading its earliest research reactor (PARR-1) from 5 MW to 10 MW, the PAEC is now preparing modernization plans for the Kanupp reactor. The upgrade plans will be carried out over the next few years and will increase the plant's capacity, improve safety and performance features, and extend its operating life.

To further increase its supply of electricity, Pakistan has been negotiating the purchase of a 900-MWe PWR from France. However, France's decision to sign the Treaty on the Non-Proliferation of Nuclear Weapons and adhere to full-scope IAEA safeguards has made conclusion of the sale unlikely. Pakistan has not signed the NPT, and its stated policy allows for inspection of imported nuclear technology, but not of technology the country has developed through its own research. Another possible purchase of a VVER from the former Soviet Union also is unlikely, given the dramatic changes in that country.

In support of the country's nuclear plans, Pakistan operates several fuel cycle facilities. The Baghalchar mine provides uranium to the Dera Ghazi Khan mill, which has an annual capacity of almost 80 thousand pounds U_3O_8. Production was at full capacity in 1991, compared to 1990 when localized fighting had closed the operation during the first part of the year. In 1991, the PAEC announced it had developed and was using a new solution mining technique on the low-grade deposits at Issa Khel and in areas where underground tunnels were not feasible. Pakistan also operates a non-safeguarded centrifuge enrichment plant at Kahuta, near Islamabad. Its current capacity of 5,000 SWU per year can be expanded to 15,000 SWU per year. The PAEC also is believed to operate at least one pilot reprocessing plant at the Kahuta site. At Kundian, the country has its own fuel fabrication facility that began operation in 1979.

PHILIPPINES

Electrical power remains in short supply in the Philippines, with blackouts and brownouts increasingly common. Nevertheless, through 1991 the government still would not permit operation of the country's nearly complete nuclear reactor. In a lawsuit filed against the reactor vendor, Westinghouse, the government alleged that PNPP-1, a 620-MWe PWR, had construction deficiencies and that Westinghouse had paid millions of dollars in bribes to former government officials under the Ferdinand Marcos regime.

The reactor has been mothballed since 1985 due to the allegations. However, in March 1992, the Philippine government and Westinghouse announced that they had finally agreed to settle the lawsuit. The agreement dictates that Westinghouse will complete construction of the nuclear plant, upgrading it to current standards. The Philippine government will pay Westinghouse US$40 million per year to operate and maintain the unit, who must sell the power generated by the plant at 2.9 cents per kWh to the Philippine National Power Corporation, who will, in turn, sell it to retail customers at a profit. Westinghouse also will provide cash and credits totalling US$100 million over three years to the Philippines. Estimates to complete the plant total $400 million; the other $300 million will be paid by the Philippines, financed by the Export/Import Bank. The allegations of bribery and construction deficiencies were never proven, and Westinghouse continues to deny them. The plant's architect/engineer, Burns & Roe, who was also named in the suit, will not pay any of the settlement. It is expected to take 3 to 4 years to bring the plant into commercial operation.

SOUTH KOREA

The year 1991 proved to be progressive for South Korea, both in terms of its continued economic growth and its advancing nuclear program. The country's nine reactors generated over 53 thousand GWh of electricity, with an average capacity factor of 84 percent **(Table 24)**. Nuclear-generated power accounted for almost 50 percent of all electricity generated in South Korea in 1991.

During the year, several significant developments occurred in the nuclear program. Construction began on Wolsong 2 during 1991; by year end, the 700-MWe CANDU reactor was approximately eight-percent complete. Perhaps the most important development occurred in July when Korea Electric Power Corporation (KEPCO) awarded ABB-CE a contract to build the long-planned Uljin units 3 and 4 (943-MWe PWRs). The decision marks not only another step forward in Korea's nuclear power production, but another opportunity for the domestic nuclear construction industry to gain additional experience. It was ABB's willingness to share its technology and experience with the various Korean firms and involve them closely in the project that weighed favorably in ABB's being awarded the contract. Another important factor, certainly, was ABB's proposed plant completion schedule of 54 to 57 months.

Economically, South Korea's output grew at nearly eight percent during 1991, a notch down from 1990's nine percent, but still impressive by worldwide standards. Although the Korean economy is showing many signs of "maturing", significant growth in electricity demand is still expected, since the average Korean citizen uses only 25 percent of the electricity the average Japanese does and 17 percent as much as an American. South Korea's potential for a huge growth in demand illustrates a serious need for future planning and further consideration of nuclear power to satisfy the country's electrical needs.

As a result, the Korean government issued a revised long-term program that called for 13 additional nuclear power stations to be in operation by 2006. Until this announcement, South Korea's nuclear-generated electrical output was expected to fall from about 50 percent today, to as little as 30 percent of total generation. The revised plan calls for five 700-MWe CANDU plants and eight 1,000-MWe PWRs. Both designs will be added in two stages, the first to be completed by 2001 (two CANDU and two PWRs), and the second by 2006 (three CANDU and six PWRs).

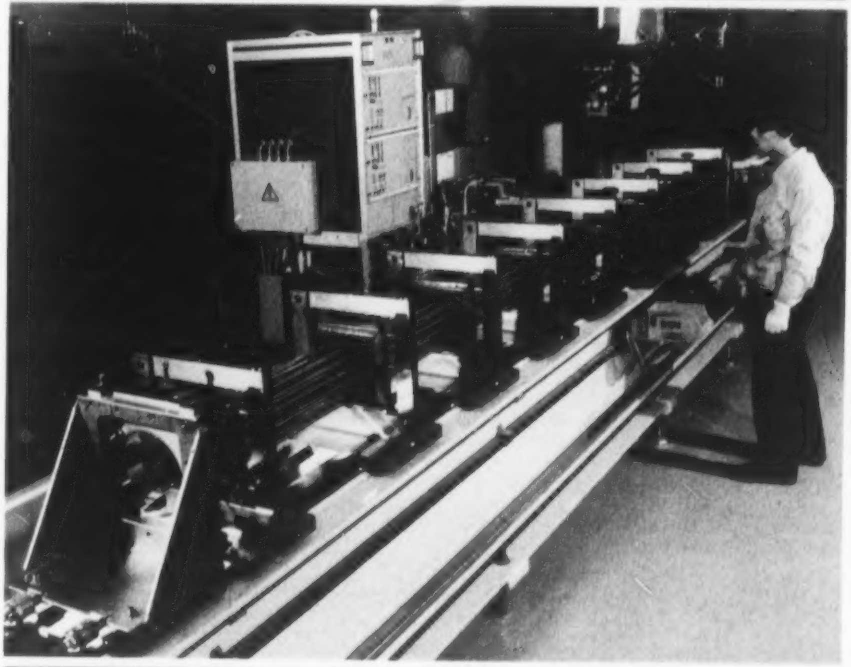

Figure 21 — Fuel Bundle Fabrication. Final assembly of PWR bundles at KNFC's Taejon fuel fabrication plant. *(Photo courtesy of KNFC)*

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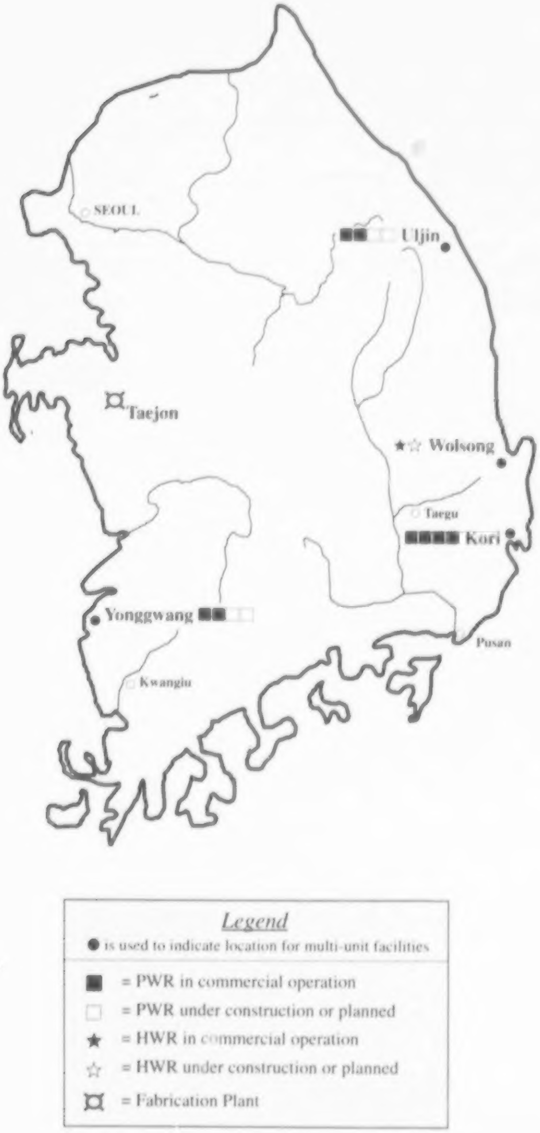
Figure 22
NUCLEAR POWER UNITS AND
FUEL CYCLE FACILITIES IN SOUTH KOREA


SEOUL
■■□□ Uljin
⌑ Taejon
★☆ Wolsong
Taegu
■■■■ Kori
Yonggwang ■■□□
Pusan
Kwangju
Legend
● is used to indicate location for multi-unit facilities
■ = PWR in commercial operation
□ = PWR under construction or planned
★ = HWR in commercial operation
☆ = HWR under construction or planned
⌑ = Fabrication Plant

Both the government and KEPCO recognize the potential problems associated with the new program. There is opposition to sites selected for any kind of generating facility, and this is exacerbated if the proposed station uses nuclear power. Realizing this, the program also calls for dramatic increases in informational and educational programs directed to the public. Major efforts have already begun to add programs that actively involve local people near actual sites and other innovative ideas to reduce misconceptions about nuclear energy. In addition to nuclear plant site studies, the government created a new corporation to study, recommend, and implement the difficult issues associated with spent-fuel storage and the back end of the fuel cycle. Given Korea's history of safely managing nuclear fuel as a dependable source of electricity, nuclear's already impressive share of total generation (50 percent), and a strong government commitment to public education, South Korea's nuclear program should continue to progress.

Table 24
NUCLEAR POWER UNITS IN SOUTH KOREA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Kori 1	KEPCO[2]	556	PWR	1978	89	4,358
Kori 2	KEPCO	605	PWR	1983	86	4,557
Kori 3	KEPCO	895	PWR	1985	74	5,823
Kori 4	KEPCO	895	PWR	1986	80	6,245
Uljin 1	KEPCO	920	PWR	1988	89	7,198
Uljin 2	KEPCO	943	PWR	1989	80	6,610
Wolsong 1	KEPCO	629	HWR	1983	91	5,016
Yonggwang 1	KEPCO	900	PWR	1986	84	6,590
Yonggwang 2	KEPCO	900	PWR	1987	84	6,629
TOTAL		**7,243**		*(1991 Average:*	**84)**	**53,025**

Units Planned

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	Percent Complete[3]
Yonggwang 3	KEPCO	900	PWR	1995	50
Yonggwang 4	KEPCO	900	PWR	1996	50
Wolsong 2	KEPCO	629	HWR	1998	8
Uljin 3	KEPCO	943	PWR	1998	6
Uljin 4	KEPCO	943	PWR	1999	6
TOTAL		**4,315**			

---

[1] COD = Commercial Operation Date (actual or expected)
[2] KEPCO = Korea Electric Power Corporation
[3] Source: *Nuclear News*

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TAIWAN

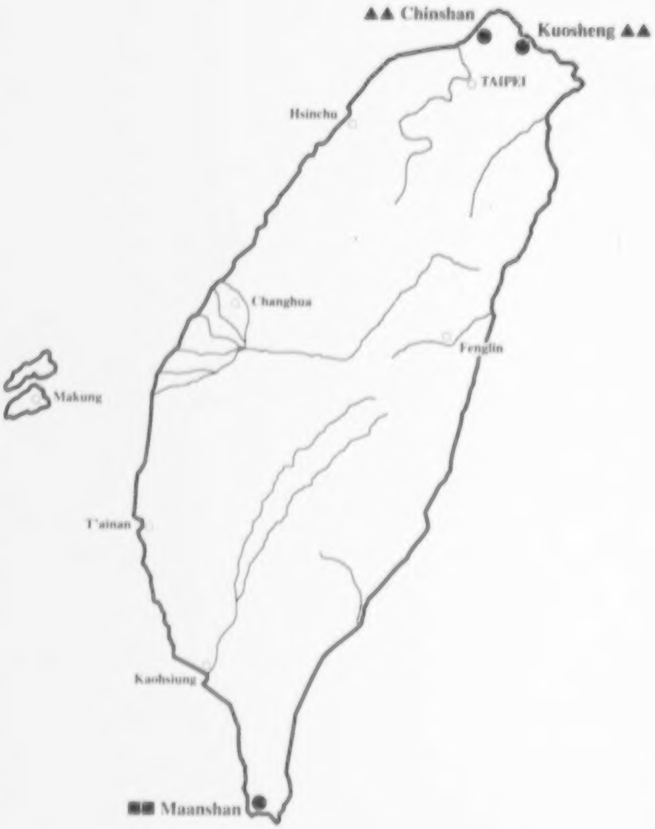
Increasing domestic energy demand, coupled with continued public opposition to nuclear plans, highlighted the year for state-owned Taiwan Power Corporation (Taipower). As a result of rapid national economic development, Taiwan's power generation capacity will have to double within ten years in order to meet projected needs. Therefore, despite public protest and the heated politics that surround this issue, the government of Taiwan is determined to move forward with plans to add significant nuclear capacity to the existing power grid.

Nuclear Power Program

Taipower currently operates six nuclear power units—four boiling water reactors and two pressurized water reactors—located at three stations with a total net capacity of 4,842 MWe (**Table 25**). Kuosheng and Chinshan stations in northern Taiwan each contain two GE-supplied BWR units (**Figure 23**). Two Westinghouse PWRs are located at Maanshan in the south (**Figure 24**). Nuclear's share of total installed capacity is approximately thirty percent, a ratio that Taipower wishes to maintain as its overall generation capacity expands.

As a result of this desire, nuclear-generated capacity is expected to increase before the end of the decade. Two 1000-MWe PWR units are again under consideration after encountering severe opposition in the early 1980s. Yenliao in northern Taiwan is the proposed location for these new units. Taipower also is studying the idea of adding reactors to the existing three stations, in response to environmental concerns. Despite government efforts to diminish fears, strong public opposition to nuclear expansion continues.

Figure 23
NUCLEAR POWER UNITS IN TAIWAN



Legend

● is used to indicate location for multi-unit facilities

■ = PWR in commercial operation

▲ = BWR in commercial operation

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Waste Management

In the area of radioactive waste disposal, Lanyu Island (approximately 80 km east of Taiwan's southern tip) has been used by Taiwan as a low-level waste disposal site since the early 1980s. Lanyu Island, now operated by Taipower, was originally governed by the Radwaste Administration of Taiwan's Atomic Energy Council. Officials estimate that the facility will be filled to capacity in approximately eight years, so efforts are underway to pinpoint a suitable alternative site.

Preliminary discussions have begun between Taiwan and the People's Republic of China on the joint disposal of high-level waste. The dialogue has centered around the possibility of depositing high-level waste material on a Chinese island off the mainland coast. This site would be donated by China in exchange for use of a facility that Taiwan would build there. If the proposal moves forward to completion, it would mark a milestone in the relations of these two governments, as well as their first cooperative effort in the nuclear field.

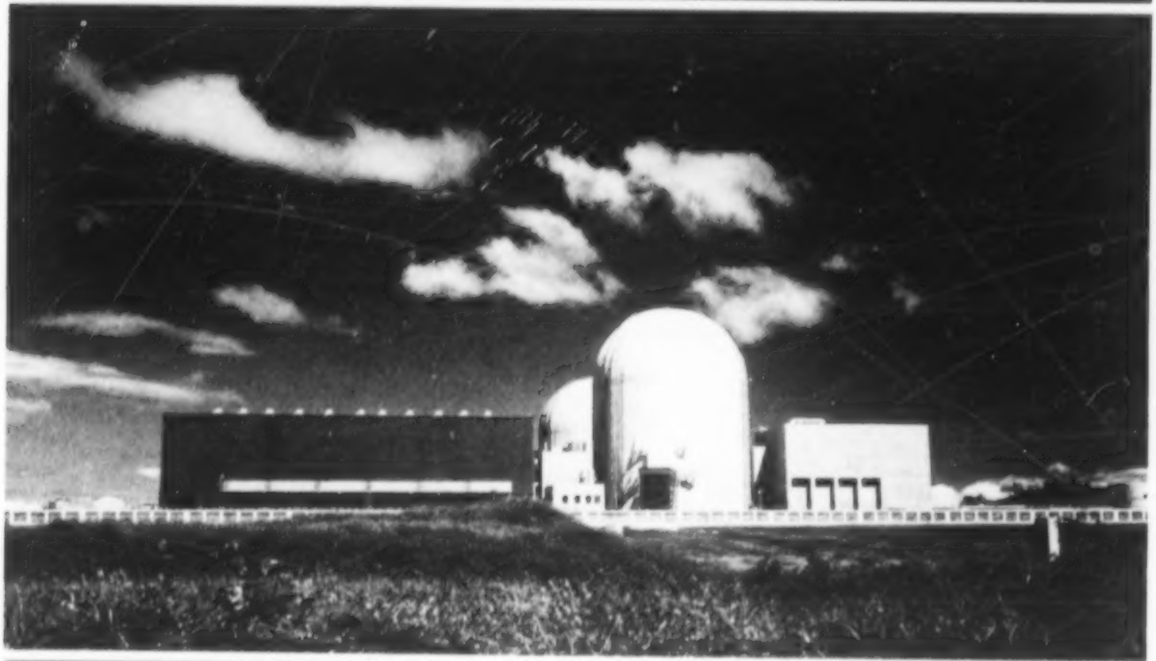

Figure 24 —Maanshan Nuclear Power Station. Taipower owns and operates the twin 890-MWe PWR station, located on the southern tip of Taiwan. *(Photo courtesy of Taipower)*

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Table 25
NUCLEAR POWER UNITS IN TAIWAN

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Chinshan 1	Taipower[2]	604	BWR	1978	83	4,403
Chinshan 2	Taipower	604	BWR	1979	72	3,797
Kuosheng 1	Taipower	918	BWR	1981	72	5,786
Kuosheng 2	Taipower	936	BWR	1983	87	7,120
Maanshan 1	Taipower	890	PWR	1984	81	6,341
Maanshan 2	Taipower	890	PWR	1985	78	6,048
TOTAL		**4,842**		*(1991 Average:*	**79)**	**33,496**

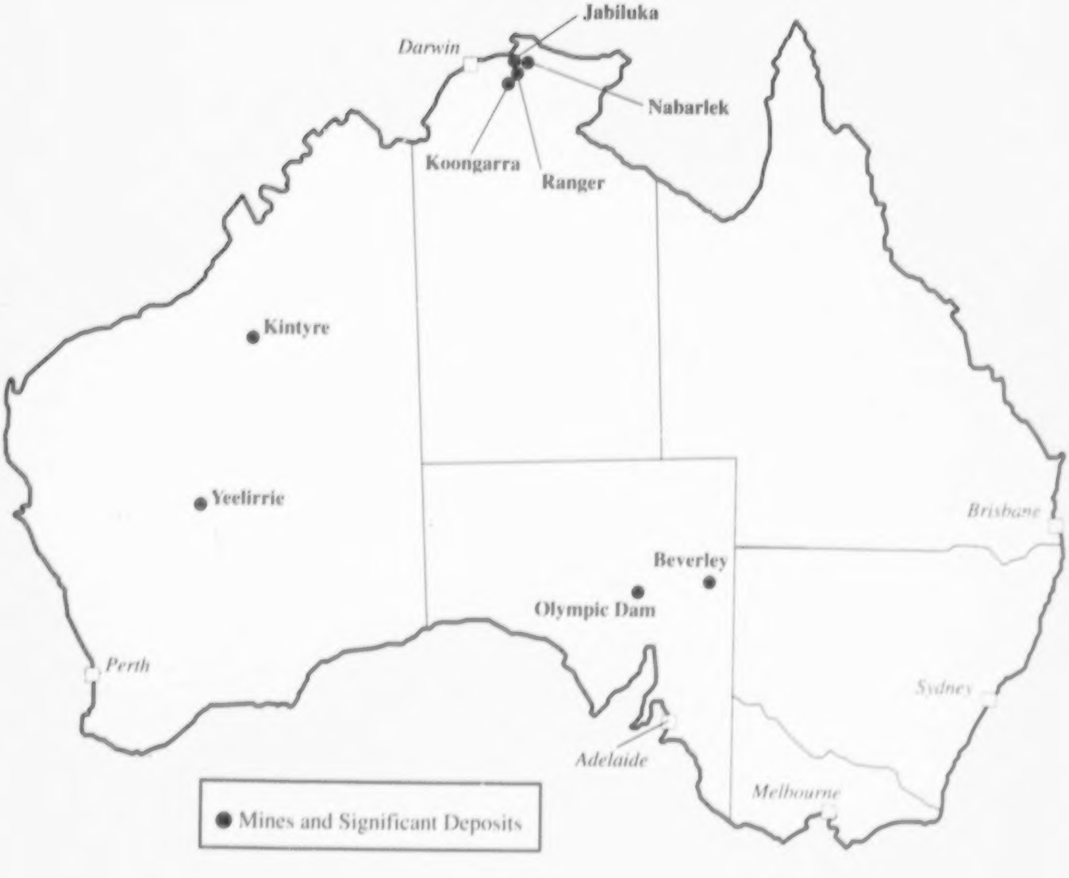
[1] COD = Commercial Operation Date
[2] Taipower = Taiwan Power Corporation

THAILAND

Thailand will be one of the fastest growing Asian economies over the next five years, as heavy investment from Japan and the newly industrialized countries of Asia boost growth to as much as nine percent annually. This growth will put an incredible strain on an already-inadequate infrastructure and power system.

The government has supported a proposal by the Electricity Generating Authority of Thailand to build a nuclear plant by the year 2000. However, the removal from office of Thai Prime Minister Chatichai Choonhaven may defer the plans for the 900-MWe reactor, as he was the strongest nuclear supporter in the government.

AUSTRALIA



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Australian uranium production in 1991 totalled 9.8 million pounds U_3O_8, up almost seven percent from the 9.2 million pounds produced in 1990. Both active Australian uranium projects, Energy Resources of Australia's (ERA) Ranger mine in the Northern Territory and the Olympic Dam project in South Australia, contributed to this increase in production.

ERA

ERA's 1991 production of 6.9 million pounds U_3O_8 was eight percent higher than 1990's total of 6.4 million pounds. Responding to continued uranium price weakness, ERA announced near year-end, a 40-percent staff reduction at Ranger and production cutbacks to levels more in line with delivery commitments. In July 1991, while taking steps to adjust to near-term market conditions, ERA also positioned itself for the longer term by acquiring Pancontinental Mining Ltd.'s massive Jabiluka deposit for A$125 million. Jabiluka, which is estimated to contain more than 450 million pounds U_3O_8, is less than 20 km from the Ranger mill. Its size and relatively high grade make it a logical candidate for processing through the Ranger facilities, should the government approve.

OLYMPIC DAM

Production at Olympic Dam (**Figure 25**), the copper-uranium-gold joint venture between Western Mining Company and BP Australia, edged up six percent, from

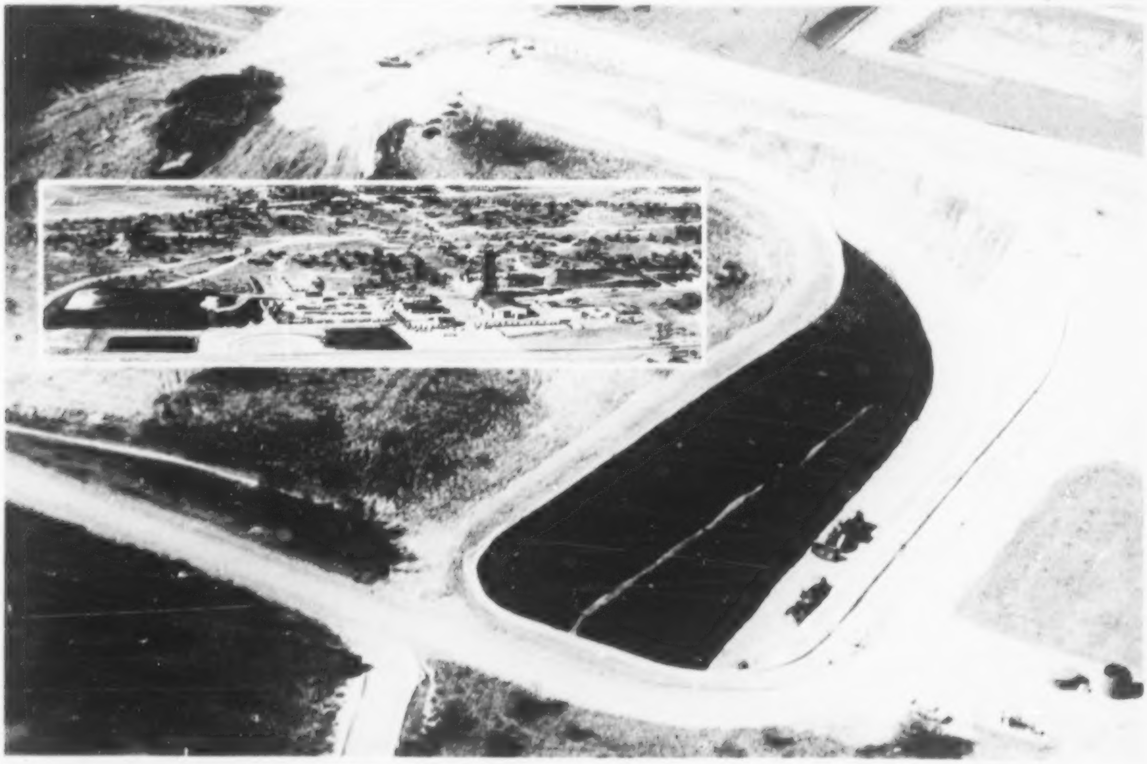

Figure 25 — Olympic Dam Mine. Machinery entering a decline portal at the project. In the inset, the mullock from the creation of a 500m shaft is on left. In the center is the Whenan Shaft head frame and winder house. On the right is the ore and metallurgical samples storage area. *(Photo courtesy of Olympic Dam Mines, Ltd.)*

2.76 million pounds U_3O_8 in 1990 to 2.93 million pounds in 1991. Because the mining plan continues to focus on copper-rich ore, the current mine expansion will lift 1992 uranium production only modestly — to 3.1 or 3.2 million pounds. Olympic Dam made substantial commercial progress during 1991, concluding new long-term contracts in the USA, Europe, and Asia. BP Australia's 49-percent share of the project remains available for sale.

OTHER DEVELOPMENTS

During its biennial conference in late June 1991, the Australian Labor Party (ALP) voted against any expansion of Australia's uranium industry. It had been expected that the ALP would, with the support of its special Uranium Policy Review Committee and a number of senior party officials, effectively abandon the restrictive three-mines policy. At the last minute, however, Prime Minister Hawke withdrew his support for such a change, repaying a debt to the anti-uranium left for its support during a leadership challenge mounted by party Treasurer, Mr. Keating. Mr. Hawke's victory was short-lived however, for later in the year Mr. Keating mounted a successful challenge and replaced Mr. Hawke as Prime Minister. To date Mr. Keating has made no pronouncement regarding his views on uranium policy. However, following its sale of Jabiluka to ERA, Pancontinental, the sharpest critic of the government's uranium policy, has ceased to be a factor in the political debate over the matter.

Cogema, the French fuel cycle conglomerate, concluded an agreement under which it is funding the exploration of and earning an interest in Queensland Mines Ltd.'s Arnhemland leases. Separately, Cogema has also taken up a number of other exploration leases in the Northern Territory, as has the world's largest uranium producer, Cameco.

In mid-year it was learned that the Australian government was close to a sale of its stockpile of 4.5 million pounds U_3O_8. With severe budgetary problems, the Finance Ministry, with responsibility for the sale of surplus assets, solicited proposals from a number of potential uranium buyers. However, the idea was scuttled in the face of vigorous opposition from the Ministry of Primary Industries and Energy, which successfully argued that sale of such a large quantity of uranium into an already depressed market was not in Australia's best interest.

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EUROPE

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EUROPE OVERVIEW

During 1991, Europe continued to progress toward an integrated electricity system for the continent and to establish the structures that will meld western, central, and eastern Europe into one economic community. Western Europe led the world in the massive effort to reform and revitalize central and eastern Europe.

A significant step concerning energy occurred in December 1991, when the European Energy Charter was signed by 49 countries, including the fifteen republics of the former Soviet Union, all twelve members of the European Community (EC), the USA, Japan, and Australia. The Charter establishes a framework for energy-related protocols between signatories, and sets out three major areas for action: development of trade in energy; cooperation in the energy field; and energy efficiency and environmental protection. Specifically, development of trade includes issues such as open markets, removal of administrative barriers, and modernization of industries. Cooperation in the energy field calls for coordinating energy policies and legal structures, and establishing consistent technical specifications and safety standards. Energy efficiency and environmental protection will focus on promoting an environmentally safe energy mix, and the use of renewables and clean technologies. The Charter was the first step toward a legally binding "Basic Protocol", scheduled for signing in mid-1992, that will address specifically a number of these issues.

Another important event was the release of the EC commission's draft directive on liberalizing the electricity market in the member states. The directive officially was issued on January 17, 1992, but had evolved throughout 1991. Previously, the commission had outlined three main stages in the process of opening the EC market: discussion and analysis of the concept, issuance of a directive outlining specific goals, and completion of the internal market. The first stage of discussion and analysis is complete. The release of the EC draft directive marks the beginning of the second stage and delineates three key areas scheduled to be implemented beginning January 1, 1993. The first is the end of exclusive rights to

Table 26
1991 NUCLEAR POWER GENERATION IN WESTERN EUROPE

Country	Number of Units (end of 1991)	1990 Nuclear Generation (GWh gross)[1]	1991 Nuclear Generation (GWh gross)[1]	1991 Relative To 1989
Belgium	7	42,722	42,861	+ 0.3%
Finland	4	18,948	19,225	+ 1.5%
France	56[2]	314,103	331,381	+ 5.5%
Germany	21[3]	147,194	147,247	+ 0.0%
Hungary	4	13,644	13,663	+ 0.1%
Netherlands	2	3,440	3,329	− 3.2%
Slovenia	1	4,622	4,960	+ 7.3%
Spain	9	54,264	55,576	+ 2.4%
Sweden	12	68,183	76,760	+12.6%
Switzerland	5	23,598	22,875	− 3.1%
United Kingdom	37	68,755	70,360	+ 2.3%
TOTAL	**158**	**759,453**	**788,237**	**+ 3.8%**

[1] Source: *Nucleonics Week*

[2] Includes Phénix and Superphénix, although both were shut down for much of 1991. Excludes Chooz A, decommissioned during 1991.

[3] Excludes units in the former GDR. Includes Mülheim-Kärlich, shut down since 1988, and Obrigheim, restarted in 1991.

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generate electricity and build power lines, within the context of national policies. The goal is to open investment in production to independent generators and large industrial users, yet take into account specific national concerns regarding electricity supply. Separation of the generation, transmission, and distribution areas of each utility, without changing their ownership, is the second area. The third is to allow limited third-party access to large industrial customers. These steps are to be complete by the beginning of 1996, at which time the third stage will begin, finalizing the framework that will complete the opening of the EC electricity market.

In 1991, nuclear power generation in western Europe increased by 3.8 percent over 1990 figures. The 158 reactors generated more than 788 thousand GWh in 1991 (**Table 26**). The major reason for the increased generation was the improved performance of reactors throughout western Europe: all but two countries generated more nuclear-powered electricity in 1991 than 1990. In addition, new reactors coming on-line during the year compensated for several decommissionings.

As a result of the continuing breakdown of barriers between eastern and western Europe, and the increasing cooperation involving areas such as nuclear safety and industry restructuring, all facets of the European energy industry are becoming more intertwined. By the end of the decade, all of Europe will be well on its way toward complete integration of its markets and industries.

AUSTRIA

Gemeinschaftskraftwerk Tullnerfeld (GKT), owner of the cancelled Tullnerfeld nuclear reactor project, continued examination during 1991 of various design plans for converting the plant structures and systems to accommodate a gas-fired system with an expected plant output of 700 to 900 MWe. GKT anticipates submitting a final proposal for the project to its Board of Directors by the end of 1992. If the Board approves the proposal, construction would begin in 1993, with startup scheduled for 1998. GKT staff would administer the project, with the field work implemented by a number of subcontractors.

In the meantime, despite much local opposition, Austrian authorities have approved construction of a new hydroelectric plant on the Danube River at Fraudenau, near Vienna. The plant, with an output of 150 MWe, is scheduled for operation by 1995. The plant will play an important role in Austria's electricity supply situation, because for the first time, Austria became a net importer of electricity in 1991.

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BELGIUM

Electrabel, a privately-owned utility formed through a 1990 merger of Belgium's three largest utilities, is responsible for operating the nation's seven nuclear reactors. These reactors, located at two stations, Doel and Tihange (**Figure 26**), supply about 60 percent of Belgium's electricity, and operated at an average capacity factor of 85 percent during 1991 (**Table 27**).

Electrabel and Belgium's sole public-sector utility, Société Cooperative de Production d'Electricité (SPE), own approximately 25 percent of the two 1,390-MWe PWRs under construction at Chooz, France, near the French-Belgian border. Electrabel also has a 50-percent interest in the 305-MWe Chooz A reactor, which was shut down in October 1991, six years ahead of schedule, due to high operating costs. To compensate for the shutdown, Electrabel receives an equivalent amount of electricity from the Tihange 1 power plant, located in Belgium, in which Electricité de France has a 50-percent interest. Plans for expansion of Belgium's domestic nuclear program have been deferred since 1988, although the government has announced it will review plans for an eighth reactor in 1995.

Belgium has been involved in the development of France's REP-2000 advanced reactor program, as well as the SNR-300 fast breeder reactor at Kalkar, Germany. Due to lengthy delays in the licensing process, Germany decided in May 1991 to halt the development of the Kalkar project. Belgium had invested well over US$600 million in the project since its inception nearly 20 years ago. As a result of the closure, Belgium began negotiations with Germany to protect its interests and seek compensation.

Synatom, Belgium's nuclear fuel supply company, having contracts with suppliers in all major uranium-producing regions of the world, encourages supply diversity. Synatom is a shareholder in Eurodif and covers a significant share of its enrichment requirements from this source.

Synatom also is a major contributor to the financing of ONDRAF-NIRAS, Belgium's National Agency for Radioactive Waste and Fissile Material. Synatom has substantial reprocessing contracts with Cogema. Construction of a facility at Mol for interim storage of vitrified waste from reprocessing is scheduled for completion in 1994.

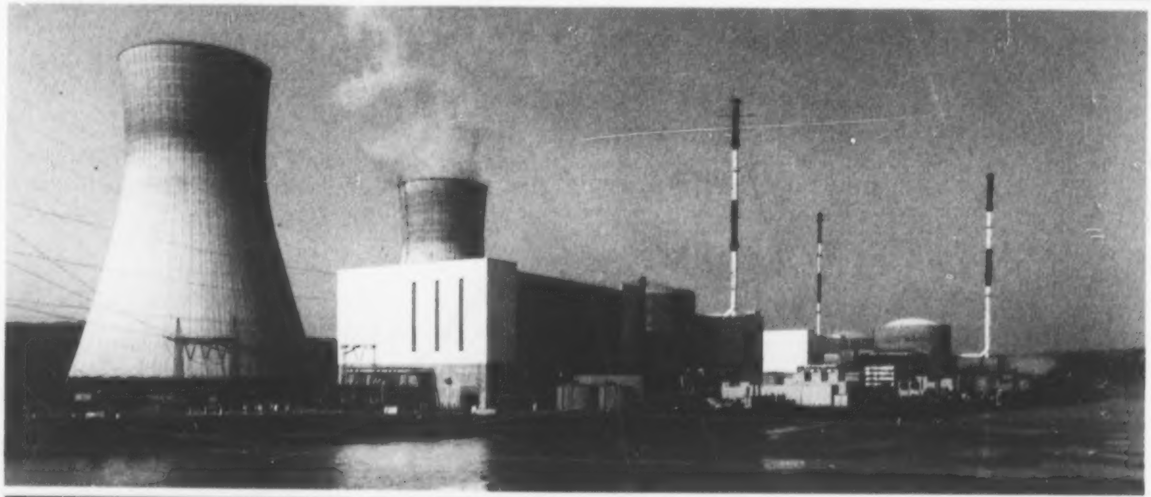

Figure 26 — Tihange Nuclear Power Station. (*Photo courtesy of Synatom*)

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EUROPE

Table 27
NUCLEAR POWER UNITS IN BELGIUM

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Net Capacity Factor (percent)	1991 Electricity Generation (GWh net)
Doel 1	Synatom	400	PWR	1975	87	3,059
Doel 2	Synatom	400	PWR	1975	79	2,785
Doel 3	Synatom	900	PWR	1982	86	6,797
Doel 4	Synatom	1,010	PWR	1985	84	7,474
Tihange 1	Synatom	870	PWR	1975	81	6,205
Tihange 2	Synatom	901	PWR	1983	86	6,826
Tihange 3	Synatom	1,020	PWR	1985	86	7,657
TOTAL		**5,501**		*(1991 Average:*	**85)**	**40,803**

[1] COD = Commercial Operation Date

Table 28
NUCLEAR POWER UNITS IN BULGARIA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]
Kozloduy 1	SEU[2]	408	VVER	1974
Kozloduy 2	SEU	408	VVER	1975
Kozloduy 3	SEU	408	VVER	1981
Kozloduy 4	SEU	408	VVER	1982
Kozloduy 5	SEU	953	VVER	1988
TOTAL		**2,585**		

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	Percent Complete
Kozloduy 6	SEU	953	VVER	1992	100

[1] COD = Commercial Operation Date (actual or expected)
[2] SEU = State Economic Union

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BULGARIA

Bulgaria's six-unit Kozloduy nuclear power station on the Danube River was the object of international criticism during 1991, after an IAEA Operational Safety Review Team recommended closure of the plant. Kozloduy has supplied about one-third of the country's electricity, and brown-outs are widely reported in the country as a result of shutting down some of the reactors for safety improvements.

Following the June 1991 publication of the IAEA report on Kozloduy in which the OSART cited numerous safety concerns about equipment and operating procedures, the World Association of Nuclear Operators and the European Community sent funds and technical expertise to Bulgaria to assist with plant improvements. Among the European companies contributing to the effort are Scottish Nuclear Ltd., Nuclear Electric plc, EdF, Electrabel, RWE Energie AG, and the Spanish utility group UNESA.

Four of the six Kozloduy units are first-generation Soviet VVER-440s. The first two units were shut down for safety upgrades early in 1991, after operating during 1990 with load factors of 71 percent and 69 percent, respectively. Units 1 and 2, which came on line in 1974 and 1975 (**Table 28**), were the two reactors most severely criticized by the IAEA. In December 1991, IAEA, WANO, and Bulgarian authorities reached an agreement on plans to upgrade Units 1 and 2 to enable them to operate through 1995. Units 3 and 4 operated during most of 1991. Unit 5, a 953-MWe VVER first connected to the grid in 1989, was shut down for several months in mid-year, but resumed operation temporarily in September 1991. By year end, Unit 6, also a 953-MWe VVER, was operating at full power and was expected to reach commercial operation in 1992. However, with Unit 6 operating there were not enough qualified operators to continue to run Unit 5, so it was shut down again before the end of the year. Bulgaria is concentrating now on training enough operators so that both 953-MWe plants can be run simultaneously.

Fabricated fuel for the Kozloduy reactors is supplied by Techsnabexport of Russia under a long-term contract. Under the contract, Techsnabexport may accept the return of spent fuel elements if a price is agreed with the Bulgarians.

Uranium mining in Bulgaria was curtailed substantially during 1991, with production estimated at approximately half the country's annual capacity of two million pounds U_3O_8. Production comes from three mining centers: Bukhovo, Elesnica, and Plovdiv. Bukhovo and Elesnica are conventional mills processing ore from both open-pit and underground mines. The Plovdiv production center processes uranium supplied by an extensive solution mining network in the region (**Figure 27**).

Late in 1990, the former Soviet Union terminated the contract under which it had purchased all Bulgarian uranium production. The Bulgarian government has begun efforts to restructure the uranium industry, but progress has been slow due to political uncertainty in the country. With the victory of a coalition of democratic parties in recent election however, the Ministry of Industry, which oversees uranium mining and the company Redki Metali, is expected to take concerted action to close down uneconomic uranium mines and redirect industry to the development of other resources.

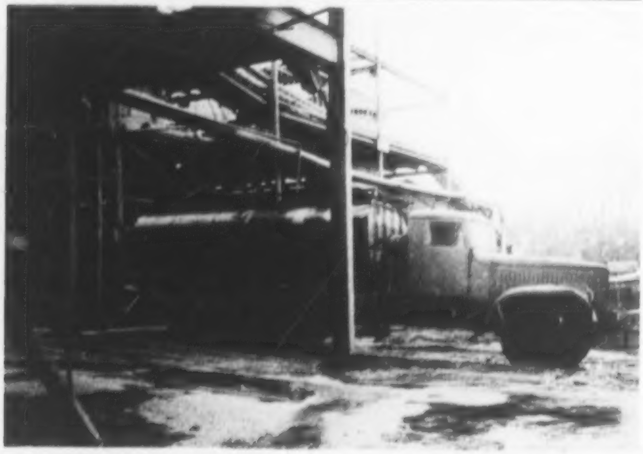

Figure 27 — Plodiv Uranium Processing Plant. A truck being loaded with slurry at the Plodiv ISL project. (*Photo courtesy of SEU*)

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CIS
COMMONWEALTH OF INDEPENDENT STATES

The year 1991 was a historic one for the Soviet Union, and indeed, for the world. The attempted coup in August was the catalyst for the increased pace of change. As consequences, the Communist Party of the Soviet Union was officially banned, the Soviet Union was dissolved at the end of the year, most price controls were lifted in January 1992, and the organs of government were being redefined and restructured.

These events affected all levels of society, including the commercial nuclear power and nuclear fuel industries. At the end of 1991 and into the beginning of 1992, there was a major restructuring of these industries. The Soviet Ministry of Atomic Energy and Industry (converted to a Russian ministry in early 1992) remained responsible for the operation of all the CIS reactors, even though ownership of the units was claimed by the individual republics where the reactors are located. The 45 reactors that operated during 1991 in the CIS (one was shutdown in October) contributed about 12 percent of the Commonwealth's total electricity generation.

POLICY AND POLITICAL DEVELOPMENTS

The dissolution of the Soviet Union had begun in earnest early in the year, with the secession of the three Baltic states: Estonia, Latvia, and Lithuania. At the end of 1991, the Soviet Union ceased to exist, and 12 states were officially formed. The largest of these is Russia or the Russian Federation. Most of the responsibilities of the former Soviet government were assumed by Russia. In late 1991, led by Russia, Ukraine, and Belarus (formerly Byelorussia), most of the newly independent republics formed the Commonwealth of Independent States (CIS), a loose political organization of fully independent governments.

Among the responsibilities and functions assumed by Russia were those for international nuclear and military treaties, as well as the regulation and operation of nuclear power and nuclear fuel cycle facilities. On January 29, 1992, Russian President Boris Yeltsin signed a decree to officially dissolve the Soviet Ministry of Atomic Energy and Industry and to create a new Ministry of Atomic Energy of the Russian Federation (Minatom).

In addition to this alignment of government duties within Russia, with the creation of the new independent republics came the transfer of responsibility for nuclear power and nuclear fuel facilities to the governments in which the facilities are located. The facilities included operating nuclear power plants in Lithuania, Ukraine, Kazakhstan, and Russia, as well as two shutdown units in Armenia. All nuclear fuel processing facilities of the former Soviet Union are located on Russian territory, but the uranium concentrates production facilities located in Kazakhstan, Kyrgyzstan, Tajikistan, Ukraine, and Uzbekistan are administered by the governments of those newly created states.

In the midst of the former Soviet Union's dissolution, there was considerable interest in the USA about CIS trade in nuclear fuel. Specifically, some committees of the United States Senate requested that studies of non-market economy trade practices be carried out by the US General Accounting Office and the US International Trade Commission.

Later in the year, on November 8, 1991, certain uranium producers with US production interests, and the Oil, Chemical, and Atomic Energy Workers Union filed a petition with the US Department of Commerce and the US International Trade Commission charging that uranium was being dumped (i.e., sold at less than fair market value) in the United States by the Soviet Union and the individual republics that were part of the former Union. The petition claimed that Soviet trade practices were causing injury and threatening further injury to the US uranium industry.

On December 3, 1991, the staff of the ITC held a public conference to investigate the petition. The purpose of the on-going ITC investigation is to determine if injury to the domestic uranium industry has been caused by the Soviet imports. After hearing the testimony and receiving briefs from each party elaborating their respective positions, the ITC staff assembled and analyzed the issues for the commissioners assigned to the case, who then made a preliminary determination whether to dismiss the petition or continue the investigation.

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On December 18, the ITC commissioners made a preliminary decision that the petition merited further investigation. The procedure was continued by the International Trade Administration of the Department of Commerce, which has 160 days to ascertain if, in fact, the Soviet uranium marketed in the USA was sold at less than fair market value.

NUCLEAR POWER PROGRAM

The former Soviet republics of the Commonwealth of Independent States, constitute the third-largest nuclear-generating nation in the world, after the USA and France. Nearly all of the former Soviet Union's operating reactors are located within three republics: Russia, Ukraine, and Kazakhstan. The CIS currently operates 44 reactors with a net capacity of 30,400 MWe (**Table 29**), including 25 VVERs, 17 RBMKs, and 2 FBRs. Together, these reactors accounted for about 12 percent of all electricity generated in the CIS during 1991. The majority of the Commonwealth's operating reactors are located within the borders of Russia. Thirty-nine units at nine stations are located in that republic; 15 reactors at five stations are located in Ukraine; and one FBR is sited in Kazakhstan (**Figure 29**).

No new reactors entered commercial operation in the CIS in 1991. One reactor, Chernobyl 2, was shut down permanently as a result of an early October fire in its turbine hall. The Ukrainian Parliament also voted to close Units 1 and 3 no later than 1993, two years earlier than previously scheduled. Currently, Ukraine's 15 operating reactors contribute over 20 percent of the republic's total electricity generation.

The Ministry of Atomic Energy remains responsible for the operation of all reactors in the CIS (although the stations are now owned by the individual republics), as well as for the Ignalina station in now-independent Lithuania. The government of Lithuania formally took possession of the twin 1,380-MWe RBMK station on August 27 and made the Lithuanian Ministry of Energy its new owner. In October, the Lithuanian government and Minatom reached an agreement whereby Minatom would continue its responsibility for the operation, safety, fuel, and equipment of the Ignalina station until Lithuania can sign, ratify, and enact the conditions of the Treaty on the Non-Proliferation of Nuclear Weapons.

In other developments, the republic of Armenia announced it plans to restart the Armenia nuclear power station to help alleviate a serious energy shortage. The station, containing two VVER-440s, was shut down in 1989 due to public opposition and safety concerns. The decommissioning plans have been suspended and the republic hopes to have Unit 2 at the station operating by the end of 1992.

In Russia, seven reactors still are officially under construction, primarily 1,000 MW-class VVERs. One year ago, ten reactors were under construction in the Soviet Union. Since that time, Khmel'nitski 2, a 950-MWe VVER scheduled to begin generating power in 1991, fell victim to a Ukrainian government moratorium and has not reached commercial operation. Construction has ceased on the Russian reactor Tatar 1, as well. This 950-MWe VVER being built on the banks of a Volga tributary is located in a seismically active area and will be converted to a fossil-fueled plant within the next few years. Construction on the Russian reactors Kalinin 3 and 4 also stopped during the year. Unit 4 construction has been halted pending the results of an environmental impact study; construction on Unit 3 has restarted and commercial operation is planned in 1993.

Despite the innumerable challenges facing the CIS, the governments of most republics, particularly Russia, recognize the need for nuclear power to provide energy required for economic growth. As recently as September, the Soviet government had plans to install up to 12,600 MWe of additional nuclear capacity by the year 2000. While achieving this goal may be unlikely, Russia does have more than 6,600 MWe of capacity still under construction, and the growing energy shortages make it likely that some, if not most, of this capacity eventually will be completed.

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NUCLEAR FUEL PRODUCTION

All of the Commonwealth's nuclear fuel processing facilities are located in Russia. With CIS' increased participation in the market, a substantial amount of information about nuclear fuel production capability and activities became available during 1991. This includes two fuel element fabrication plants and four uranium enrichment plants (**Figure 28**), one of which has an operating uranium hexafluoride conversion plant.

In the area of uranium concentrates production, about 40 percent of the former Soviet Union's production has come from *in-situ* leaching, using a highly efficient technology first developed within the Soviet Union in the 1960s. Of the recent uranium mining activity, about 30 percent of mine production has come from Russia, 30 percent from Kazakhstan, 30 percent from Uzbekistan, and the remaining 10 percent from Ukraine. (The Ukrainian facility near Zholtye Vody was shut down in 1991.)

As in the West, there has been considerable pressure on the uranium industry in the former Soviet Union, due to the total cessation of production for nuclear weapons and a slowdown in the domestic nuclear power program. Consequently, more than a dozen uranium mines have been closed during the past two years.

The locations of four enrichment plants were released in 1991. These plants are located near the cities of Ekaterinburg (formerly Sverdlovsk) in the Ural mountains, Tomsk, Krasnoyarsk, and Angarsk. The Ural Electrochemical Plant (UEP) near Ekaterinburg is the oldest and largest of these. Production was begun at the UEP in 1949, using gaseous diffusion. The first installation of gas centrifuges began at the plant in 1962, and this new technology had completely replaced the old gas diffusion technology by the 1980s. The UEP is the facility used to provide enrichment services for natural uranium feed to be exported, whereas the enrichment plant near Tomsk was dedicated to the re-enrichment of reprocessed uranium beginning in 1991.

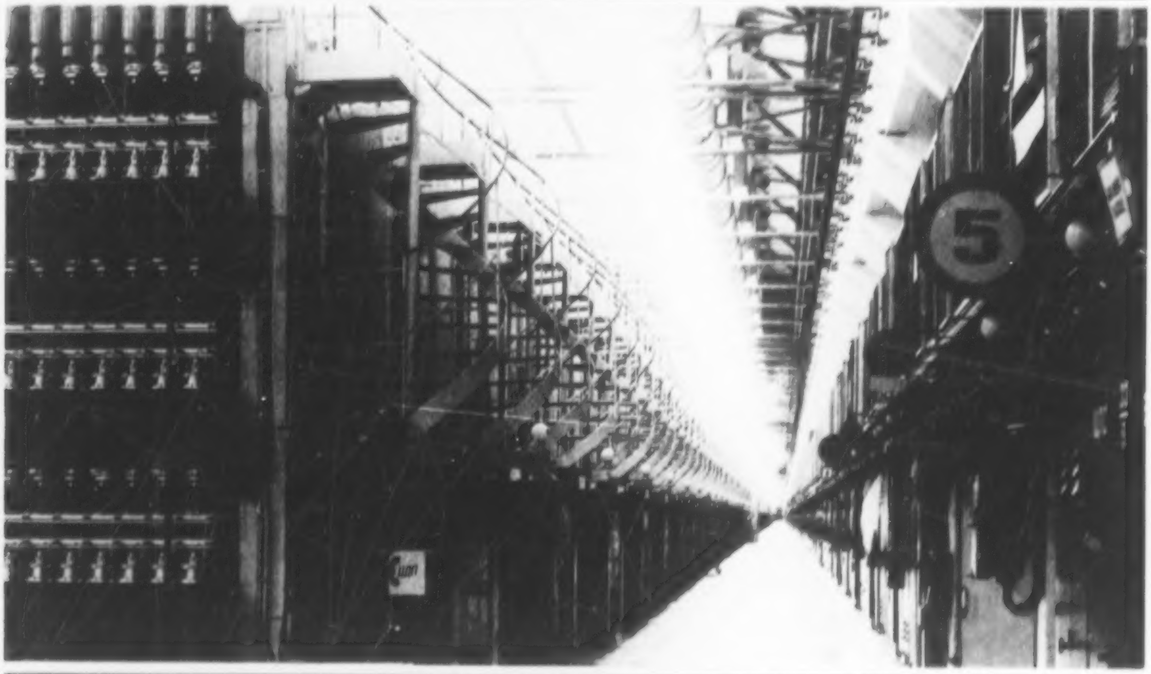

Figure 28 — Russian Centrifuge Enrichment Plant. An interior view showing cascades at an operating gas centrifuge plant. (*Photo courtesy of Minatom*)

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The capacity of these individual plants and of the total capacity of all Russian enrichment plants remained classified at the beginning of 1992; however, exports to Europe have been as high as 4 million SWU per year in the 1980s, and officials of the former Soviet Ministry of Atomic Energy and Industry stated that Russia had the capability to export some 10 million SWU per year by the late 1990s. A major upgrading program is in place for enrichment, replacing old-generation centrifuge machines with newer, more efficient machines.

During 1991 and the first part of 1992, several major events occurred involving restructuring of the nuclear fuel industry in the countries of the former Soviet Union. In late 1991, Techsnabexport, the former ministry's nuclear fuel trading company with exclusive authority to export uranium and uranium processing services, was being reconstituted as Techsnabexport, Ltd., a private stock company registered in Russia. In addition, uranium concentrates producers of the former Soviet Union formed a new association called AtomRedmetZoloto to focus their activities in producing and marketing natural uranium concentrates.

Another important development during 1991 was the formation of a Russian-American joint-venture company to market uranium and nuclear fuel processing services to the West, primarily for the USA and Asia. The joint-venture shareholders include NUEXCO Exchange AG; Techsnabexport; the Ural Electrochemical Plant; and the Priargunsky Mining Combinat (Russia's sole operating uranium concentrates production facility). Global Nuclear Services and Supply Limited, as this joint venture is called, established its primary office in Washington, DC, for marketing uranium and enrichment services. Long-term contracts for providing uranium enrichment services were signed with Commonwealth Edison Company in late summer 1991 and with Wisconsin Electric Power Company in early 1992.

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Table 29
NUCLEAR POWER UNITS IN THE COMMONWEALTH OF INDEPENDENT STATES

Units In Operation in the Republic of Russia

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]
Balakovo 1	MAEI[2]	950	VVER[3]	1986
Balakovo 2	MAEI	950	VVER	1988
Balakovo 3	MAEI	950	VVER	1989
Beloyarsk 3	MAEI	560	LMFBR[4]	1981
Kalinin 1	MAEI	950	VVER	1985
Kalinin 2	MAEI	950	VVER	1987
Kola 1	MAEI	411	VVER	1973
Kola 2	MAEI	411	VVER	1975
Kola 3	MAEI	411	VVER	1982
Kola 4	MAEI	411	VVER	1984
Kursk 1	MAEI	650	RBMK[5]	1977
Kursk 2	MAEI	650	RBMK	1979
Kursk 3	MAEI	925	RBMK	1984
Kursk 4	MAEI	925	RBMK	1986
Novovoronezh 2	MAEI	336	VVER	1970
Novovoronezh 3	MAEI	385	VVER	1972
Novovoronezh 4	MAEI	385	VVER	1973
Novovoronezh 5	MAEI	950	VVER	1981
Smolensk 1	MAEI	925	RBMK	1983
Smolensk 2	MAEI	925	RBMK	1985
Smolensk 3	MAEI	925	RBMK	1990
Sosnovy Bor 1	MAEI	650	RBMK	1974
Sosnovy Bor 2	MAEI	650	RBMK	1976
Sosnovy Bor 3	MAEI	925	RBMK	1980
Sosnovy Bor 4	MAEI	925	RBMK	1981
Troitsk 3	MAEI	90	RBMK	1960
Troitsk 4	MAEI	90	RBMK	1960
Troitsk 5	MAEI	90	RBMK	1961
Troitsk 6	MAEI	90	RBMK	1963
TOTAL		**18,445**		

Units Under Construction in the Republic of Russia

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]
Balakovo 4	MAEI	950	VVER	1992
Balakovo 5	MAEI	950	VVER	1995
Balakovo 6	MAEI	950	VVER	1998
Kalinin 3	MAEI	950	VVER	1993
Kostroma 1	MAEI	950	VVER	1994
Kostroma 2	MAEI	950	VVER	1995
Kursk 5	MAEI	925	RBMK	1995
TOTAL		**6,625**		

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[1] COD = Commercial Operation Date (actual or expected)

[2] MAEI = Ministry of Atomic Energy and Industry (of the former Soviet Union)

[3] VVER = Vodo-Vodyanoi Energetichesky Reaktor

[4] LMFBR = Liquid Metal Fast Breeder Reactor

[5] RBMK = Reaktory Bolshoi Moshchnosti Kanalnye

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Table 29

NUCLEAR POWER UNITS IN THE COMMONWEALTH OF INDEPENDENT STATES

(*continued*)

Units In Operation in the Republic of Ukraine

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]
Chernobyl 1	MAEI[3]	650	RBMK[4]	1978
Chernobyl 2[2]	MAEI	650	RBMK	1979
Chernobyl 3	MAEI	925	RBMK	1982
Khmel'nitski 1	MAEI	950	VVER[5]	1988
Rovno 1	MAEI	361	VVER	1981
Rovno 2	MAEI	384	VVER	1982
Rovno 3	MAEI	950	VVER	1987
South Ukraine 1	MAEI	950	VVER	1983
South Ukraine 2	MAEI	950	VVER	1985
South Ukraine 3	MAEI	950	VVER	1989
Zaporozhe 1	MAEI	950	VVER	1985
Zaporozhe 2	MAEI	950	VVER	1985
Zaporozhe 3	MAEI	950	VVER	1987
Zaporozhe 4	MAEI	950	VVER	1988
Zaporozhe 5	MAEI	950	VVER	1989
TOTAL		**12,470**		

Units In Operation in the Republic of Kazakhstan

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]
BN-350	SCAE[6]	135	LMFBR[7]	1973

[1] COD = Commercial Operation Date

[2] Chernobyl 2 was decommissioned in October 1991.

[3] MAEI = Ministry of Atomic Energy and Industry (of the former Soviet Union)

[4] RBMK = Reaktory Bolshoi Moshchnosti Kanalnye

[5] VVER = Vodo-Vodyanoi Energetichesky Reaktor

[6] SCAE = State Committee for Atomic Energy

[7] LMFBR = Liquid Metal Fast Breeder Reactor

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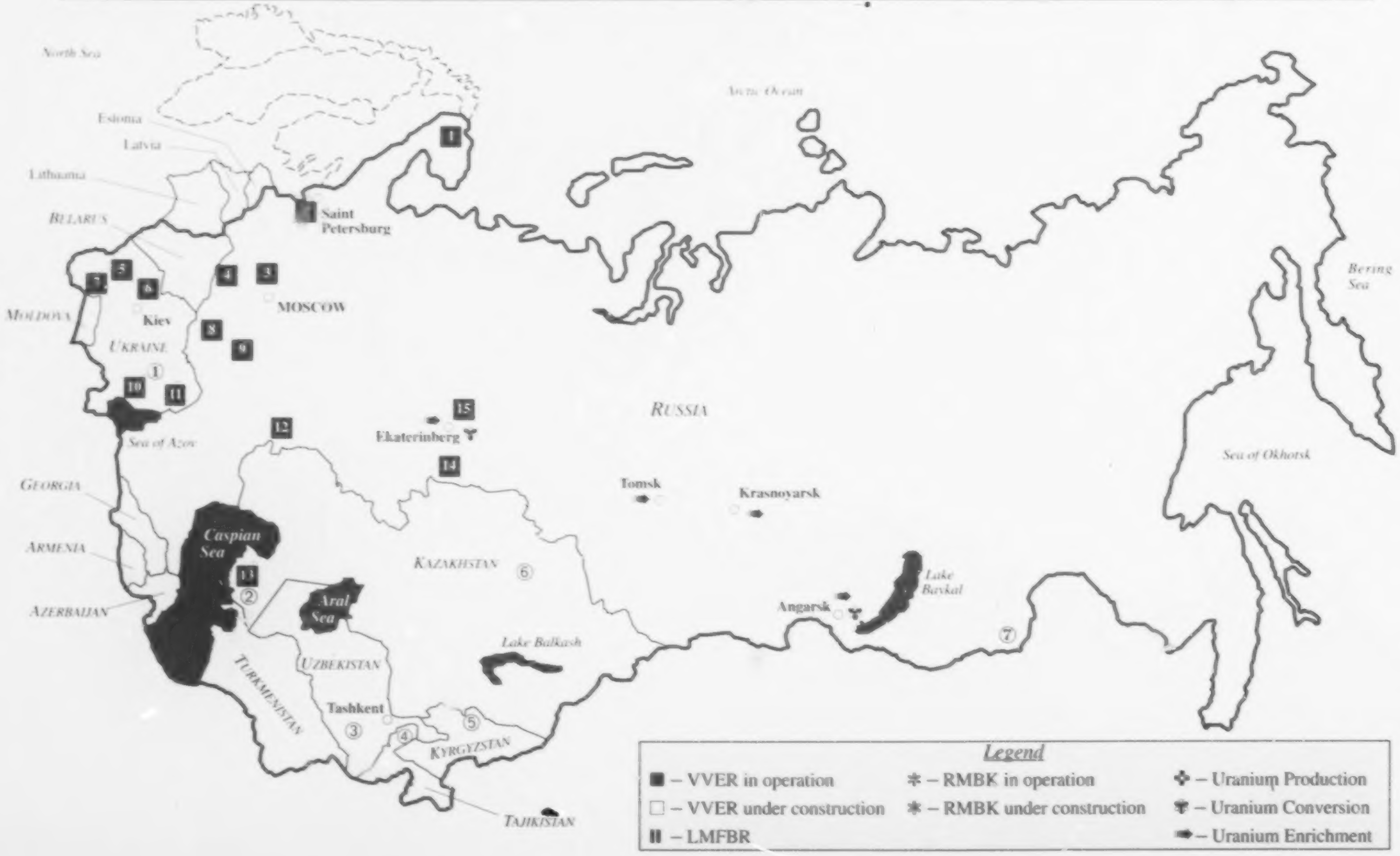
Figure 29

NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES IN THE COMMONWEALTH OF INDEPENDENT STATES

- 1 Kola ■■■■
- 2 Sosnovy Bor ✱✱✱✱
- 3 Kalinin ■■□
- 4 Smolensk ✱✱✱
- 5 Rovno ■■■
- 6 Chernobyl ✱✱
- 7 Khmel'nitski ■
- 8 Kursk ✱✱✱✱✱
- 9 Novovoronezh ■■■■
- 10 Zaporozhe ■■■■■
- 11 South Ukraine ■■■
- 12 Balakovo ■■■□□□
- 13 BN-350 (Schevchenko) ‖
- 14 Troitsk ✱✱✱✱
- 15 Beloyarsk ‖
- ① Eastern Works ✣
- ② Caspian ✣
- ③ Navoi ✣
- ④ Chkalovsk ✣
- ⑤ Kyrgyz ✣
- ⑥ Tselinnij ✣
- ⑦ Argun ✣



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CSFR

CZECH AND SLOVAK FEDERAL REPUBLIC

Eight 408-MWe VVERs operated in the Czech and Slovak Federal Republic (CSFR) during 1991, and six other units are under construction. Česke Energetické Závody (CEZ) is the operator of the four-unit Dukovany station in the Czech Republic and oversees the construction of two 892 MWe VVERs at Temelin. Plans for a third and fourth unit at Temelin were halted in early 1990. Slovenský Energetický Podnik (SEP) operates the four-unit Bohunice station in Slovakia and is building four more 408-MWe VVERs at Mochovce (**Table 30**). Together, the two operating stations have a total net capacity of 3,264 MWe, and generate almost 30 percent of the CSFR's electricity.

The CSFR has become a loose federation since free elections were held in June 1990. CEZ and SEP coordinate power distribution through a federal agency, but plan capacity independently. Both utilities continue to have regional government support for their nuclear power programs.

CEZ has actively solicited IAEA review of operations at Dukovany, as well as participation of Western vendors in the Temelin project. The utility sought preliminary bids from several vendors for two additional Temelin units during 1991. Westinghouse is working with Skoda, the Czech engineering firm, on the current Temelin construction

Table 30
NUCLEAR POWER UNITS IN THE CZECH AND SLOVAK FEDERAL REPUBLIC

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]
Bohunice 1	SEP[2]	408	VVER	1981
Bohunice 2	SEP	408	VVER	1981
Bohunice 3	SEP	408	VVER	1985
Bohunice 4	SEP	408	VVER	1985
Dukovany 1	CEZ[3]	408	VVER	1985
Dukovany 2	CEZ	408	VVER	1986
Dukovany 3	CEZ	408	VVER	1987
Dukovany 4	CEZ	408	VVER	1987
TOTAL		**3,264**		

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]
Mochovce 1	SEP	388	VVER	1993
Mochovce 2	SEP	388	VVER	1994
Mochovce 3	SEP	388	VVER	1995
Mochovce 4	SEP	388	VVER	1996
Temelin 1	CEZ	892	VVER	1994
Temelin 2	CEZ	892	VVER	1996
TOTAL		**3,336**		

[1] COD = Commercial Operation Date (actual or expected)
[2] SEP = Slovenský Energetický Podnik, S.P.
[3] CEZ = Ceske Energeticke Zavody

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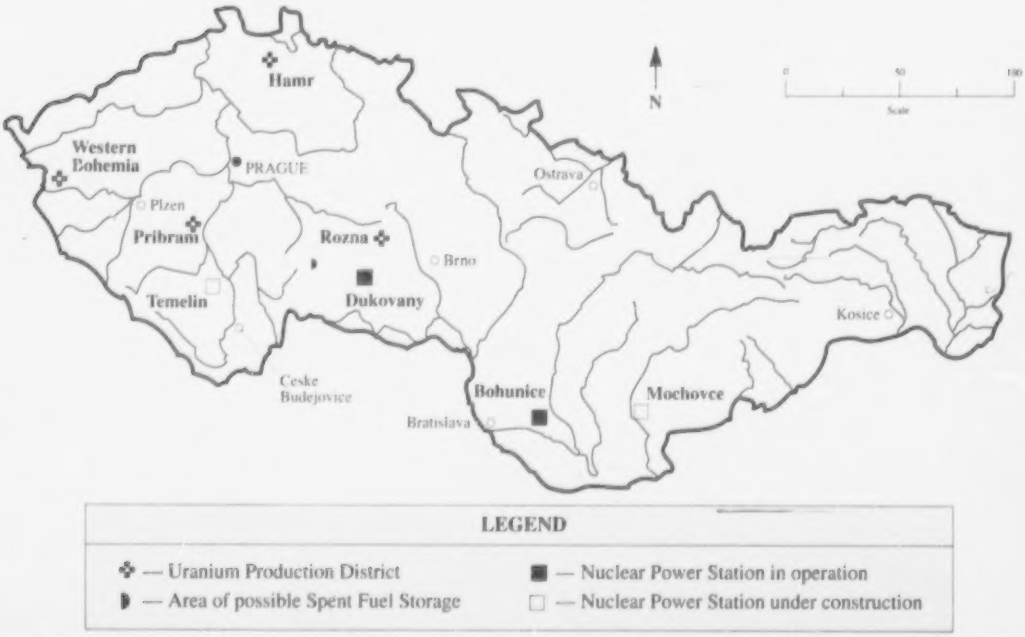
Figure 30
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES
IN THE CZECH AND SLOVAK FEDERAL REPUBLIC


Hamr
N
0
50
100
Scale
Western Bohemia
PRAGUE
Ostrava
Plzen
Pribram
Rozna
Brno
Temelin
Dukovany
Kosice
Ceske Budejovice
Bohunice
Mochovce
Bratislava
LEGEND
✣ — Uranium Production District
◗ — Area of possible Spent Fuel Storage
■ — Nuclear Power Station in operation
☐ — Nuclear Power Station under construction

project. In Slovakia, Siemens is cooperating with ŠEP to replace the instrumentation and control systems at Mochovce 1 and 2, which are nearing completion. SEP received international attention early in 1991 after a series of minor incidents at Bohunice, located near the Austrian border. The CSFR government has announced it plans to operate the Bohunice units through at least 1995, once safety retrofits are finished.

Fabricated fuel for the reactors at Bohunice and Dukovany is supplied by Techsnabexport of Russia under long-term contracts. Under the contracts, Techsnabexport may accept the return of spent fuel elements if a price can be agreed for the final disposal.

Československy Uranový Průmysl (CSUP), the Czech uranium producer, is negotiating with Western vendors to form a joint venture to construct a VVER fuel element manufacturing plant in the CSFR. The fabrication plant would come on line after 1995 to supply reload fuel to reactors in central and eastern Europe, in competition with the Russians. Westinghouse and Framatome are involved in the bidding, and BNFL is offering oxide conversion services for the new plant. The CSFR signed a cooperation agreement with France late in 1990, covering joint studies on uranium mining in the Czech Republic, domestic fuel fabrication, and spent fuel management.

CSUP, a major uranium producer in past years, began drastic reductions in its mining activities during 1990 and 1991. Following a government directive, the producer closed its conventional mines at Pribram in Central Bohemia, formerly the center of the Czech uranium industry, and moved its headquarters to Straz in Northern Bohemia, near the German and Polish borders. The company also is phasing out conventional mines in Western Bohemia and South Moravia, consolidating its activities in the Straz region. Most production in the future will come from solution mining of the Hamr deposit in the Straz region (**Figure 30**), although a reduced level of conventional mining will continue around Straz. Total 1991 production is estimated at about five million pounds U_3O_8. Concentrates required for use in CSFR reactors are transported to Russia for conversion; excess domestic production accumulates in a national reserve.

FINLAND

Each of Finland's four nuclear power plants operated very well throughout 1991, achieving an average capacity factor of 91 percent (**Table 31**). Late in the year Perusvoima Oy (PVO), a subsidiary of Finland's two operating utilities, Imatran Voima Oy (IVO) and Teollisuuden Voima Oy (TVO), received seven different plant proposals to supply the country's planned fifth nuclear power plant. These include 1,170-MWe and 1,350-MWe BWRs by ABB Atom to be located adjacent to the existing ABB twin reactors at the Olkiluoto plant site (**Figure 31**); a 1,040MWe VVER offered by Atomenergoexport of the former Soviet Union for the Loviisa plant site, where there are already two VVER-440 units; and a 1,110-MWe and a 1,380-MWe reactor, either as PWRs for the Loviisa site, or as BWRs for the Olkiluoto site, offered by Nuclear Power International, a company jointly owned by Siemens and Framatome.

PVO finished the technical and commercial evaluation of the offers at the end of February 1992. The Ministry of Trade and Commerce is scheduled to complete its review of the project by April, and if the review is positive, the project will be then presented to the Finnish Parliament in June 1992 for a final decision. The plant is anticipated to be operational in 1998. If a BWR concept is chosen, TVO will be responsible for the plant's operation; if a PWR concept is chosen, IVO will assume responsibility for its operation. In either case, IVO and TVO will have an equal share in the produced power.

Construction of TVO's final repository for storage of low- and intermediate-level waste was completed during the year. The license for placing the repository into operation is expected in 1992. Studies continued on five prospective sites for the final repository of spent nuclear fuel arising from the BWR plants. Spent nuclear fuel from the present and proposed future VVER plants at the Loviisa site is transported back to Russia for final disposal.

Finland's demand for electric power continues to grow at the rate of about 3 percent per year. To cover such increased demand, the country has been importing power

Table 31
NUCLEAR POWER UNITS IN FINLAND

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Loviisa 1	IVO[2]	445	PWR	1977	87	3,361
Loviisa 2	IVO	445	PWR	1981	89	3,442
Olkiluoto 1	TVO[3]	710	BWR	1979	95	5,873
Olkiluoto 2	TVO	710	BWR	1982	92	5,731
TOTAL		**2,310**		***(1991 Average:***	**91)**	**18,407**

[1] COD = Commercial Operation Date
[2] IVO = Imatran Voima Oy
[3] TVO = Teollisuuden Voima Oy

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in an amount equivalent to the output of a 1,000-MWe plant from its eastern and western neighboring countries. A 650-MWe coal-fired plant is under construction by IVO to reduce this import level, with the plant expected to reach operation in early 1993.

Russia remains the source for IVO's fabricated fuel and contained uranium for its Loviisa plants. TVO purchases the majority of its natural uranium needs under long-term supply contracts, while its enrichment needs are divided between supply from Russia and Urenco.

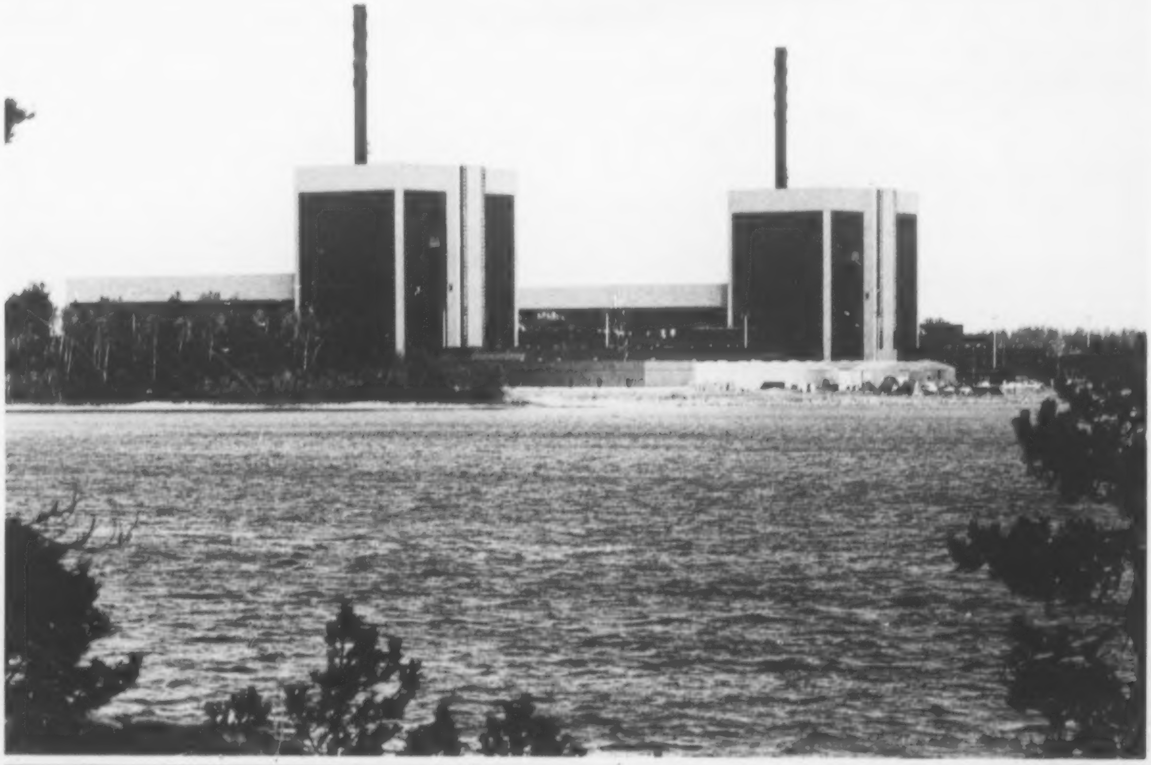

Figure 31 — Olkiluoto Nuclear Power Station. Two 710-MWe BWRs are owned and operated by Teollisuuden Voima Oy. For 1991, Units 1 and 2 had capacity factors of 95 and 92 percent, respectively. *(Photo courtesy of TVO)*

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FRANCE

Electricité de France (EdF) brought three new reactors into commercial operation during 1991: Cattenom 3, a 1,300-MWe PWR; Golfech 1, a 1,310-MWe PWR; and Cattenom 4, a 1,310-MWe PWR. The first two officially began operating in February; the latter, at the end of the year. The entry into service of the Cattenom units brought to full capacity the four-unit station located on the Moselle River near Luxembourg and Germany (**Figure 33**). Swiss utilities own approximately 30 percent of Cattenom Units 3 and 4, while Badenwerk of Germany owns five percent of Units 1 and 2.

In 1991, nuclear power generation in France increased by about five percent over the 1990 level. The country's 54 operating nuclear units generated more than 317 TWh, some 75 percent of total power generation. These totals do not include either Phénix or Superphénix, neither of which operated during the year.

Only two reactors remain in the final stages of construction: Penly 2 and Golfech 2. EdF plans to bring the units into commercial operation in 1992 and 1993, respectively. Two 1,450-MWe units, Chooz B1 and B2, are under construction near the Belgian border. Chooz A, a 305-MWe PWR in service since 1967, was shut down for decommissioning in October 1991. Nuclear power plants in France are listed in **Table 32**.

Early in 1991, EdF placed an order with Framatome for Civaux 1, a 1,455-MWe PWR scheduled for service in 1998. EdF's president, Pierre Delaporte, noted that a decision on Civaux 2 would not be made until mid-1992 at the earliest. EdF has adequate installed capacity for at least the next decade, and is continuing research and development on a future generation of PWRs to supplement and eventually replace existing nuclear units. In an interview in April 1991, Mr. Delaporte suggested that the first units of the next generation reactors would not be installed until around 2005.

Capacity utilization at the existing nuclear stations equalled 65 percent in 1991, about the same as 1990. Over the past few years, EdF has had extended outages at several plants for steam generator repair and reactor vessel inspection. Low water levels in some parts of the country have led to reduced capacity use and substitution of thermal

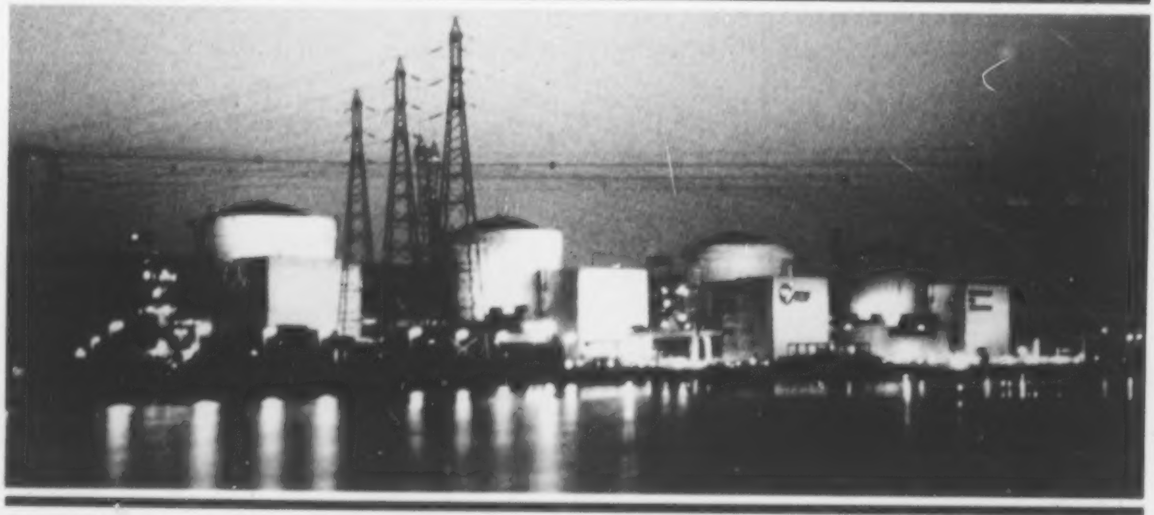


Figure 32 – Tricastin Nuclear Power Station. *(Photo courtesy of EdF)*

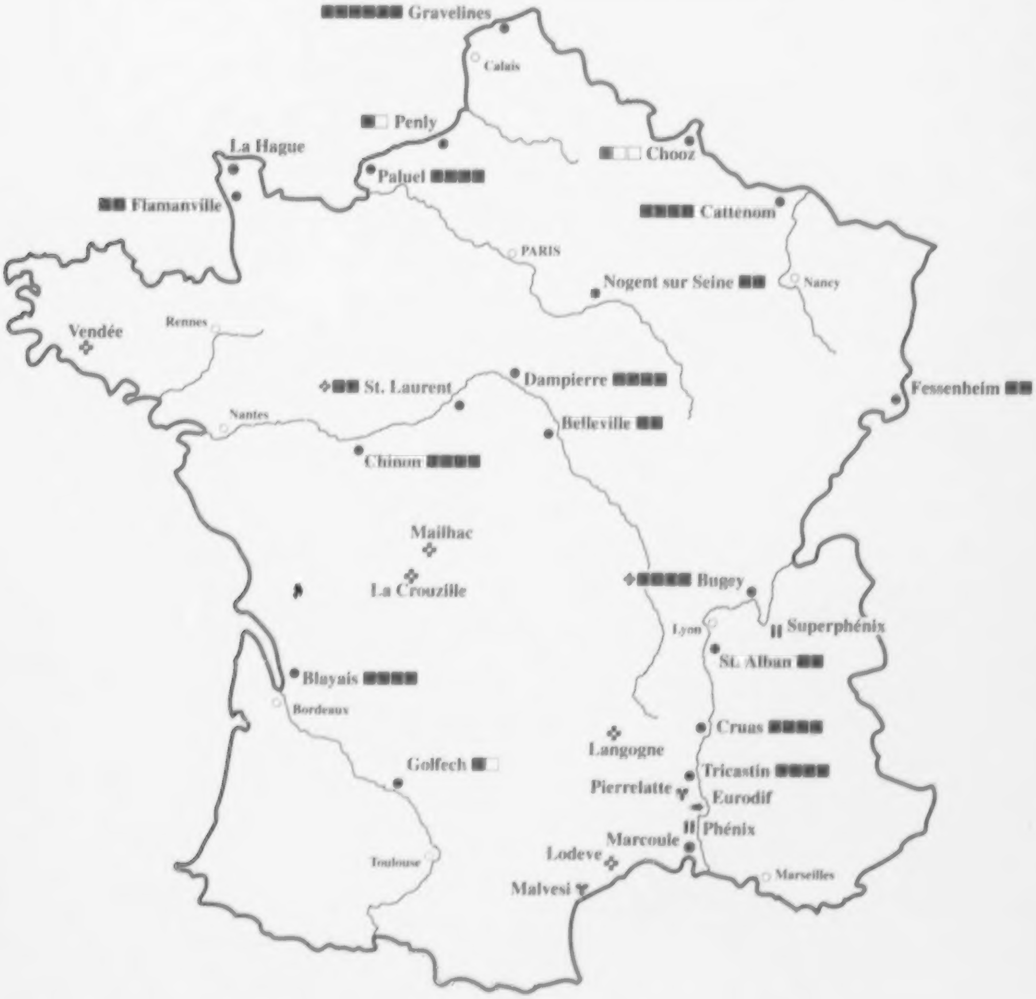
Figure 33

NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES IN FRANCE

Legend

● is used to indicate location for multi-unit facilities
Symbols below also indicate location when used with single unit facilities

■ = PWR in commercial operation
□ = PWR under construction or planned
■ = PWR decommissioned
◆ = GCR in commercial operation
❚❚ = LMFBR under construction or planned
✥ = Uranium Production Site
✥ = Conversion Plant
➡ = Enrichment Plant
✹ = Reprocessing Plant



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power generation. In addition, the Superphénix fast-breeder reactor has been shut down for technical and political reasons since July 1990; France's prototype FBR, Phénix, also was out of service during 1991 for technical reasons.

EdF continued to market its services abroad during 1991. The utility exported some 58.5 TWh, with Switzerland, Italy, and the UK the principal buyers. This represents a 12-percent increase in the level of electricity exports compared to 1990. When combined with the 1.9 TWh (29 percent) decrease of electricity imports, EdF's export balance rose an impressive 18 percent during 1991. EdF also began exporting substantial amounts of power to Spain under a long-term contract with the Spanish utility Redesa.

Figure 34 — Gravelines Nuclear Power Station. Six 910-MWe PWRs operating in northern France. (*Photo courtesy of EdF*)

Negotiations with central European utilities for power generation and distribution agreements progressed slowly during 1991. EdF continued to pursue an interest in the eastern German utility VEAG, but terms of compensation were not reached with the German utilities that are co-owners of VEAG. The companies involved had originally proposed payment by providing the Germans an interest in EdF's planned Civaux station, although this offer was declined. Meanwhile, EdF's proposal to build and operate a PWR station in Hungary appeared to make little progress during 1991, as the Hungarian government has not yet decided whether to build additional nuclear plants.

FUEL CYCLE

EdF began a comprehensive review of its fuel supply during 1991. After aggressively reducing purchases and inventory during the previous two years, the utility re-evaluated its procurement and inventory policies. As a result of government policy to maintain a level equivalent to at least three years' forward consumption, uranium inventories in France remain high, although EdF recently indicated that the required level may be lowered in the future. Most of EdF's inventory during 1991 was held in the form of concentrates, so increased conversion and enrichment purchases were required. The company developed near-term business with several suppliers outside of France, including converters, enrichers, and fabricators. Through its joint venture with TOTAL for uranium production and exploration in North America, EdF was directly involved in uranium mining and marketing during 1991.

Cogema remained EdF's major uranium supplier, providing at least 75 percent of the utility's uranium under two long-term contracts. Cogema produced about 5.3 million pounds U_3O_8 from its domestic French mines

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during 1991, a decrease of about 15 percent from 1990. The company also has key investments in Cominak and Somaïr in Niger, Comuf in Gabon, Amok in Canada, Pathfinder Mines in the USA, and Energy Resources of Australia. Early in 1992, Cogema announced an agreement to purchase a controlling interest in Urangesellschaft mbH of Germany, which also owns shares in Somaïr and ERA, as well as Rössing in Namibia. UG also is active in trading nuclear fuel from the former Soviet Union.

From its domestic mining in France, TOTAL produced approximately 1.2 million pounds U_3O_8 during 1991, which it sold to EdF. Concurrent with EdF's purchase of Malapai Resources of the USA in 1990, TOTAL and EdF combined forces to pursue uranium mining and exploration in the USA. TOTAL's US subsidiary, Total Minerals Corporation (Tomin), now acts on behalf of both French companies. Tomin increased its portfolio of long-term supply contracts during 1991, while maintaining significant uranium reserves.

Natural UF_6 conversion by Comurhex increased during 1991, mainly due to higher demand from EdF. The French converter reported a strong year and high capacity utilization. Comurhex also operates France's reconversion business for reprocessed uranium.

Eurodif's enrichment supply business recovered similarly, with EdF resuming normal SWU purchases after a year of dramatic inventory reduction. Eurodif's principal shareholder, Cogema, handles international marketing for the enricher. The long-standing financial dispute between France and Iran over Iranian participation in Eurodif was finally resolved in the past year.

After introducing the initial spent fuel rods into the UP3 reprocessing plant in August 1990, Cogema operated the new facility for its first full year in 1991. In addition to EdF, Cogema's reprocessing customers include utilities in Japan, Germany, Belgium, The Netherlands, and Switzerland. Some of the plutonium from the French reprocessing plants will be manufactured into mixed oxide (MOX) assemblies at the new MELOX fabrication plant at Marcoule. EdF currently has almost 200 MOX fuel assemblies in its operating PWRs, and the utility expects recycling eventually to account for up to 15 percent of French domestic fuel supply. Cogema reportedly has arrangements with fuel cycle facilities in Russia for the enrichment of reprocessed uranium.

Waste disposal has become a politically sensitive issue in France in recent years. The French parliament passed a new law in June 1991 governing the underground disposal of radioactive wastes and fuel products. The new law provides for continued research and development by ANDRA, the responsible state agency, while deferring any final decision on a repository until 2005.

At the beginning of 1991, France and China were the only nuclear weapons states that were not signatories to the Treaty on the Non-proliferation of Nuclear Weapons. In June, the government of France declared its intention to sign the treaty, and did so at the end of 1991, although it still must be ratified by the Parliament. In September 1991, France announced that it would apply full-scope safeguards on exports of nuclear material, as part of a major arms-control initiative.

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Table 32
NUCLEAR POWER UNITS IN FRANCE

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Belleville 1	EdF[2]	1,310	PWR	1988	75	8,639
Belleville 2	EdF	1,310	PWR	1988	69	7,863
Blayais 1	EdF	910	PWR	1981	80	6,405
Blayais 2	EdF	910	PWR	1983	68	5,381
Blayais 3	EdF	910	PWR	1983	80	6,400
Blayais 4	EdF	910	PWR	1983	69	5,497
Bugey 1	EdF	540	GCR	1972	29	1,376
Bugey 2	EdF	920	PWR	1979	61	4,930
Bugey 3	EdF	920	PWR	1979	43	3,452
Bugey 4	EdF	900	PWR	1979	64	5,050
Bugey 5	EdF	900	PWR	1980	43	3,421
Cattenom 1	EdF	1,300	PWR	1987	13	1,531
Cattenom 2	EdF	1,300	PWR	1988	67	7,620
Cattenom 3	EdF	1,300	PWR	1991	—	9,744
Cattenom 4	EdF	1,300	PWR	1991	—	2,286
Chinon B1	EdF	870	PWR	1984	71	5,394
Chinon B2	EdF	870	PWR	1984	42	3,210
Chinon B3	EdF	905	PWR	1987	89	7,085
Chinon B4	EdF	905	PWR	1988	81	6,397
Chooz A	SENA[3]	305	PWR	1967	—	1,372
Cruas 1	EdF	880	PWR	1984	59	4,521
Cruas 2	EdF	915	PWR	1985	51	4,111
Cruas 3	EdF	880	PWR	1984	78	6,027
Cruas 4	EdF	880	PWR	1985	78	6,031
Dampierre 1	EdF	890	PWR	1980	83	6,444
Dampierre 2	EdF	890	PWR	1981	55	4,270
Dampierre 3	EdF	890	PWR	1981	67	5,185
Dampierre 4	EdF	890	PWR	1981	79	6,136
Fessenheim 1	EdF	880	PWR	1977	52	4,028
Fessenheim 2	EdF	880	PWR	1978	68	5,280
Flamanville 1	EdF	1,330	PWR	1986	51	5,916
Flamanville 2	EdF	1,330	PWR	1987	68	7,958
Golfech 1	EdF	1,310	PWR	1991	—	9,532
Gravelines B1	EdF	910	PWR	1980	71	5,681
Gravelines B2	EdF	910	PWR	1980	62	4,930
Gravelines B3	EdF	910	PWR	1981	79	6,308
Gravelines B4	EdF	910	PWR	1981	79	6,275

(continued on next page)

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[1] COD = Commercial Operation Date

[2] EdF = Electricité de France

[3] Chooz Unit A was decommissioned in 1991. It is owned by SENA, (Société d'Energie Nucléaire Franco-Belge des Ardennes), which is owned 50-percent each by EdF and the Belgian utilities.

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Table 32
NUCLEAR POWER UNITS IN FRANCE
(continued)

Units In Operation
(continued)

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Gravelines C5	EdF[2]	910	PWR	1985	66	5,291
Gravelines C6	EdF	910	PWR	1985	74	5,906
Nogent sur Seine 1	EdF	1,310	PWR	1988	60	6,897
Nogent sur Seine 2	EdF	1,310	PWR	1989	72	8,314
Paluel 1	EdF	1,330	PWR	1985	62	7,167
Paluel 2	EdF	1,330	PWR	1985	53	6,165
Paluel 3	EdF	1,330	PWR	1986	82	9,549
Paluel 4	EdF	1,330	PWR	1986	71	8,315
Penly 1	EdF	1,310	PWR	1990	72	8,439
Phénix	CEA[3]	233	LMFBR	1973	48	983
St Alban 1	EdF	1,335	PWR	1986	68	7,934
St Alban 2	EdF	1,335	PWR	1987	68	7,940
St. Laurent A2	EdF	450	GCR	1971	63	2,473
St. Laurent B1	EdF	915	PWR	1983	50	4,032
St. Laurent B2	EdF	880	PWR	1983	76	6,114
Superphénix	NERSA[4]	1,200	LMFBR	1986	6	613
Tricastin 1	EdF	915	PWR	1980	74	5,920
Tricastin 2	EdF	915	PWR	1980	56	4,485
Tricastin 3	EdF	915	PWR	1981	60	4,779
Tricastin 4	EdF	915	PWR	1981	72	5,743
TOTAL		**53,148**		***(1991 Average:***	**65)[5]**	**317,146**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	Percent Complete[6]
Civaux 1	EdF	1,455	PWR	1997	10
Chooz B1	EdF	1,455	PWR	1993	85
Chooz B2	EdF	1,455	PWR	1994	60
Golfech 2	EdF	1,310	PWR	1993	95
Penly 2	EdF	1,310	PWR	1992	98
TOTAL		**6,975**			

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[1] COD = Commercial Operation Date (actual or expected)

[2] EdF = Electricité de France

[3] CEA = Commisariat à l'Énergie Atomique

[4] Superphénix is owned by NERSA, a European consortium of which the shareholders are EdF (51%), ENEL (33%), and SBK (16%). SBK is owned by RWE (Germany, 68.75%), SEP (The Netherlands, 14.75%), Electronucléaire (Belgium, 16.5%) and NE (UK, 1.75%).

[5] Average does not include those units that entered commercial operation or were retired during 1991.

[6] Source: *Nuclear News*

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GERMANY

In 1991, Germany's nuclear industry continued to struggle under the effects of an increasingly antinuclear political environment. The same challenges associated with the reunification of the country that affected the German economy in 1990 also had an effect on utilities in 1991. While reunification has presented numerous opportunities for Western utilities in terms of power generation needs and industrial development, the sheer magnitude of the rebuilding and environmental cleanup task will be a challenge to German industry for years to come.

NUCLEAR POWER GENERATION

Several German reactors operated extremely well in 1991, with seven units placing in the world's top ten reactors in total electricity generation. VEW's Emsland plant, a 1,242 MWe PWR (**Figure 35**), generated almost 10,300 GWh in 1991, more than any other reactor in the world. PREAG's Grohnde unit, a 1,300-MWe PWR, ranked second worldwide, generating 9,961 GWh. As a whole, Germany's 21 reactors operated with an average net capacity factor of 71 percent and generated 139,866 GWh (**Table 33**), which accounts for more than one-third of the country's total electricity generation.

The country's nuclear power industry experienced mixed results in 1991, on one hand demonstrating continued safe operation of the reactors, but encountering considerable political intervention on the other hand. As one example, Germany's attempt to build and operate a prototype fast breeder reactor finally evaporated in March 1991, when the government and the industry parties involved with the project made a joint decision to abandon the project. Endless court battles and the State's refusal to grant the final construction permit and fuel-loading license appeared to be the chief reasons for termination of the project. Sizeable cost overruns (the parties had spent in excess of US$4 billion since 1972 attempting to realize the project), and lack of strong commitment to the fast breeder concept by most European countries undoubtedly contributed to the decision. Ironically, the project was initially greeted with enthusiasm by the same Social Democrat government in North-Rhine Westphalia when construction began. However, the effects of the Chernobyl accident and growing anti-nuclear sentiment within Germany have now led to another casualty for the German nuclear power industry.

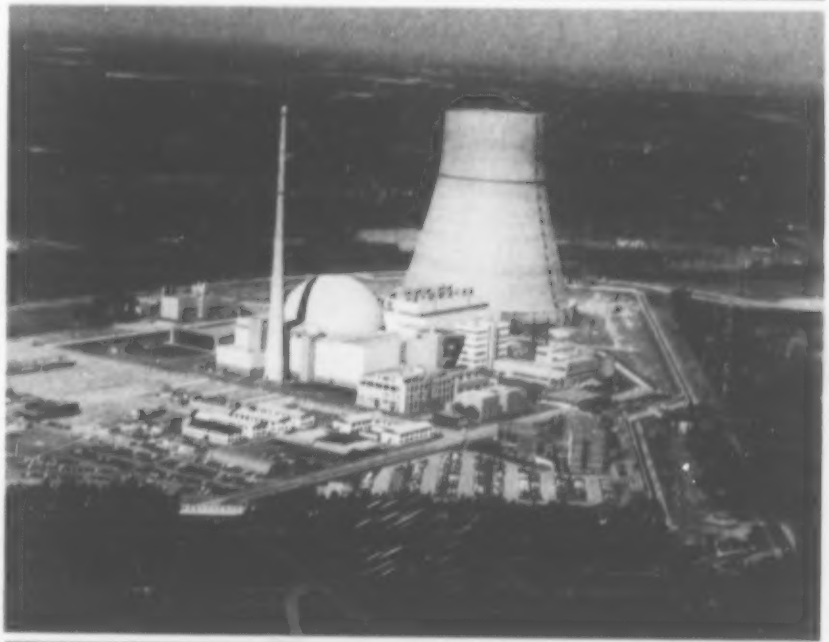

Figure 35 — Emsland Nuclear Power Station. This 1,242-MWe PWR generated more power in 1991 than any other reactor in the world. (*Photo courtesy of VEW*)

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Table 33
NUCLEAR POWER UNITS IN GERMANY

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Biblis A	RWE [2]	1,146	PWR	1975	70	6,985
Biblis B	RWE	1,240	PWR	1977	37	3,974
Brokdorf	PREAG [3]	1,326	PWR	1986	81	9,459
Brunsbüttel	HEW [4]	771	BWR	1977	57	3,826
Emsland	VEW [5]	1,242	PWR	1988	94	10,263
Grafenrheinfeld	BAG [6]	1,235	PWR	1982	90	9,734
Grohnde	PREAG	1,300	PWR	1985	87	9,961
Gundremmingen B	RWE	1,240	BWR	1984	75	8,099
Gundremmingen C	RWE	1,248	BWR	1985	75	8,201
Isar 1	BAG	870	BWR	1979	89	6,750
Isar 2	BAG	1,310	PWR	1988	85	9,767
Krümmel	HEW	1,260	BWR	1984	70	7,755
Mülheim-Kärlich	RWE	1,219	PWR	1987	—	—
Neckarwestheim 1	GKN [7]	795	PWR	1976	80	5,540
Neckarwestheim 2	GKN	1,230	PWR	1989	89	9,605
Obrigheim 1	KWO [8]	340	PWR	1969	35	1,049
Philippsburg 1	BW/EVS [9]	864	BWR	1980	81	6,166
Philippsburg 2	BW/EVS	1,268	PWR	1985	89	9,863
Stade	PREAG	640	PWR	1972	41	2,288
Unterweser	PREAG	1,230	PWR	1979	60	6,476
Würgassen	PREAG	640	BWR	1975	73	4,105
TOTAL		**22,414**		***(1991 Average:***	**71)** [10]	**139,866**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	Percent Complete
Kalkar	SBK [11]	295	LMFBR	Indefinite	100

[1] COD = Commercial Operation Date

[2] RWE = RWE Energie AG

[3] PREAG = PreussenElektra AG

[4] HEW = Hamburgische Elektricitätswerke AG

[5] VEW = Vereinigte Elektrizitätswerke Westfalen AG

[6] BAG = Bayernwerk AG

[7] GKN = Gemeinschaftskernkraftwerk Neckar GmbH

[8] KWO = Kernkraftwerk Obrigheim GmbH

[9] BW/EVS = Badenwerk AG/Energieversorgung Schwaben AG

[10] Average does not include those units that entered commercial operation or were retired during 1991.

[11] SBK = Schnell-Brüter Kernkraftwerksgesellschaft mbH

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On the positive side, the nation's oldest commercial reactor, the 351-MWe Obrigheim PWR, overcame a court-imposed shutdown to resume service in August 1991. The unit, which entered commercial operation in 1968 on the basis of a preliminary license, had been shut down for fourteen months as a result of a Mannheim Administrative Court ruling claiming that the plant did not have a permanent operating license. Based on review of the plant's construction and operation permits, the Federal Administrative Court overturned the previous decision in June 1991, and the state of Baden-Württemberg allowed the plant back on-line shortly thereafter.

Continuing the process begun after reunification in 1990, in early 1991 the German Economics Ministry closed down the last operating Soviet-designed VVER in Greifswald, eastern Germany. The unit was built in 1973, and like the other VVERs in eastern Germany, was shut down because of safety concerns. An oil-powered generating station has been built to replace that station's output. None of the other VVERs in eastern Germany are expected to be restarted, due to the current political atmosphere in Germany, as well as financial demands of refitting the units to the West's more stringent safety standards.

In April 1991, the Federal Ministry for Commercial Affairs estimated that decommissioning costs for all the eastern German nuclear plants could exceed US$8 billion. That same month, the ruling Christian Democratic Union announced its support of a plan that would involve building two new 1,300-MWe PWRs in eastern Germany by 1996. The units would be located at the Greifswald and Stendal

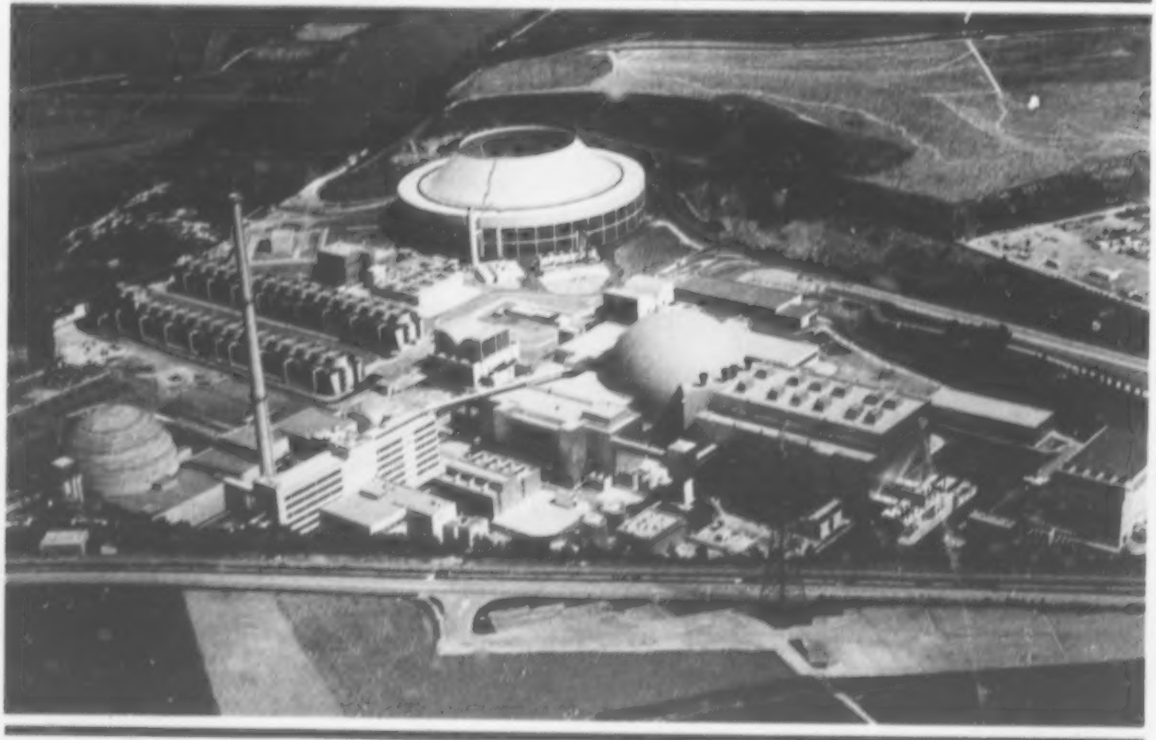

Figure 36 — Neckarwestheim Nuclear Power Station. Unit 1, a 795-MWe PWR, is shown on the left, and the dome of Unit 2, a 1,230-MWe PWR, is visible in the center. Unit 2 ranked in the top ten reactors in the world in 1991, in terms of total electrical power generated. *(Photo courtesy of GKN)*

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sites — both former sites of Soviet-designed VVERs that have been shut down. Groups in favor of this plan want an improved mix of sources for electricity generation in eastern Germany, particularly since that part of the country uses lignite coal for almost all of its electricity production. Nevertheless, the Social Democrats have vowed to block any new nuclear construction, and utilities are obviously wary of any additional nuclear-related investment in this political climate.

FUEL CYCLE DEVELOPMENTS

The Siemens fuel fabrication and mixed oxide (MOX) fuel facility at Hanau, in the German State of Hesse, was the center of attention during much of 1991. In March, in an action timed to take effect before an anti-nuclear political party assumed office, the Minister of Environment for the State of Hesse issued Siemens a definitive license for the company to operate its MOX fuel production facility. As further support for Siemens' position and recognizing that the incoming coalition of the Social Democratic Party and the Green Party would attempt to stop MOX production with challenges to the validity of the license, the outgoing Minister attached a rider to the facility license which allowed the plant to remain in operation pending resolution of any legal challenges to the license. The licensing of the MOX facility concluded the 15-year relicensing process of all of Germany's fuel cycle facilities, following a 1975 revision to the German Atomic Act. The revision required license approvals for all fuel cycle facilities to be based upon the same criteria applied to nuclear power plants.

In December, following a hydrogen explosion at a nearby non-nuclear facility, the Hanau uranium processing works were closed down pending inspection and verification of the hydrogen systems used at the plant. There were also concerns regarding the operating license of the facility, as the original license was issued on the basis that the work at the facility was "chemical" in nature. But with MOX fuel being added, opponents charged that the work was now "nuclear" and thus was subject to more stringent criteria. Siemens did not disagree with that stance, but stated the plant's original design was so conservative that it still was in compliance with the "nuclear" regulations. To prove this, a series of tests were carried out which verified the adequacy of the hydrogen system design, and on January 6, 1992, the uranium processing plant was allowed to restart operations. The plant, which manufactures both natural uranium enriched fuel and MOX fuel, is critical in the German nuclear industry as it supplies approximately three-fourths of the fuel elements used in the country's nuclear plants. Although the facility continues to operate, the licensing issue for the plant has not been completely resolved and additional tests are being conducted.

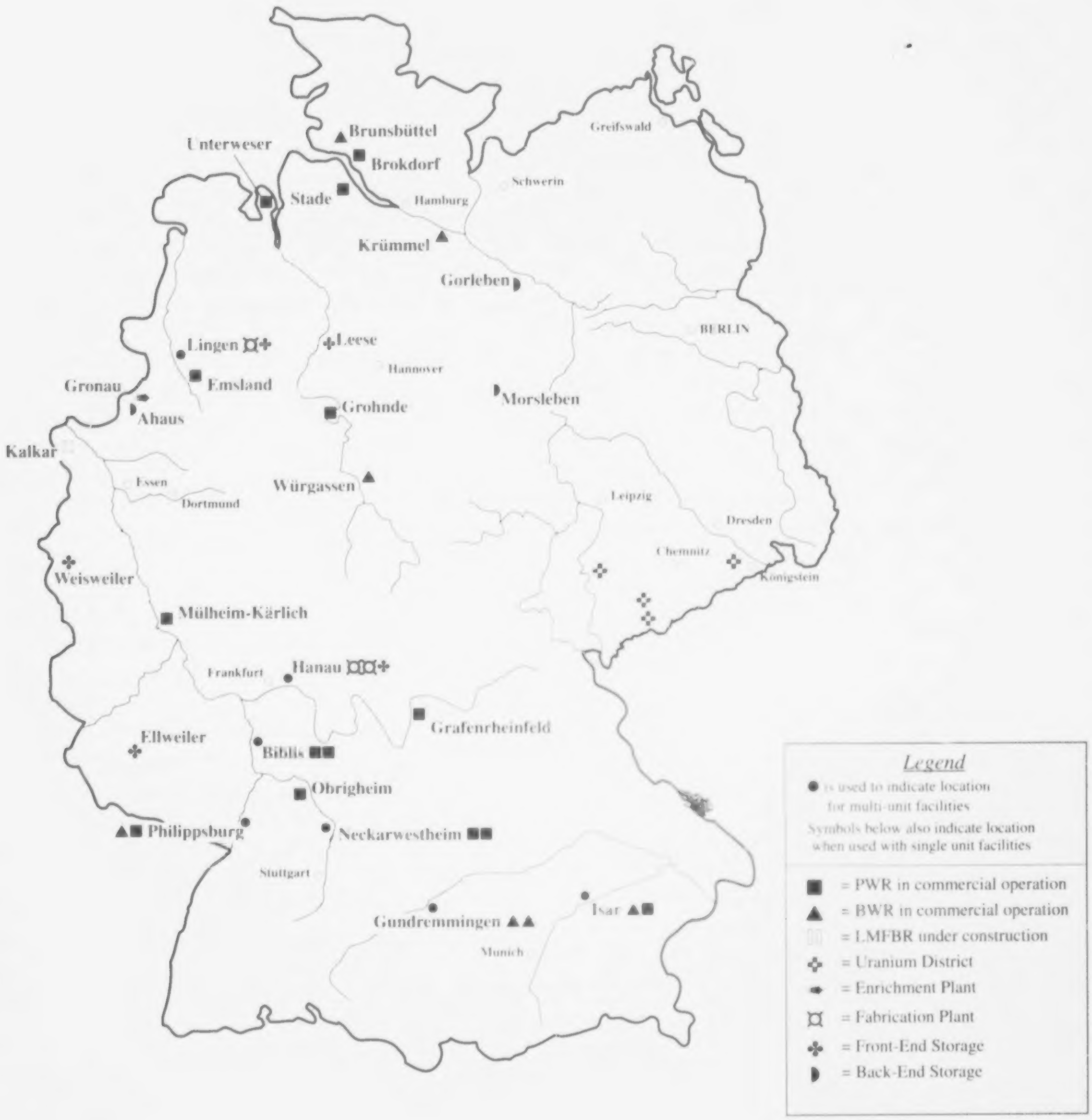
Also falling victim to the differences between unified Germany's safety regulations and those of the former East Germany was the Morsleben nuclear waste site. The East German permit was ruled by the Magdeburg District Court to be invalid, despite the fact that the Treaty of Unification apparently granted the facility a ten-year license as of July 1, 1990.

The invalidation of the Morsleben permit, combined with the legal challenges blocking progress at Konrad and Gorleben, Germany's only other two candidates for long-term radioactive waste disposal, increase the uncertainty of the country's efforts to identify a disposal site. This issue is quickly becoming critical, as German utilities must begin taking back wastes produced from their reprocessing contracts with British Nuclear Fuels plc and Cogema by 1994.

URANIUM PRODUCTION

The Wismut uranium mining enterprise near the CSFR border ceased its mining operations in 1991, due to environmental concerns and high production costs. In May 1991, the Soviet and German governments signed an agreement whereby the ex-Soviet Union gave up its 50-percent share in the Wismut mining complex in exchange for a release from liability for any environmental cleanup at the mines. This arrangement, while probably inevitable, was no doubt favorable to the Russians, since estimates of the cleanup costs have ranged from US$7 billion to as high as US$20 billion, and it is unlikely that the German government will ever recoup any of those costs from the assets at the site. In August, a consortium of Canadian firms signed an agreement with Wismut to provide expertise and technology to clean up some 40 mine and mill tailing sites within the complex.

Figure 37
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES IN GERMANY



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HUNGARY

Like the nuclear power programs of other former COMECON countries, Hungary's program began in the 1970s in cooperation with the Soviet Union. The Hungarian Electricity Board (Magyar Villamos Müvek Tröszt—MVMT) oversees all the country's power plants, including Paks. The station, operated by the state-owned utility Paksi Atomerőmű Vállatat (PAV), currently has four reactors operating at the station, each a VVER-440 (**Table 34**). The Paks station accounts for only about one quarter of Hungary's total installed electric capacity, but generated approximately half of all domestically produced electricity in 1991. The entire station has a remarkable lifetime capacity factor exceeding 86 percent.

With a projected net growth in energy demand of 1.5 percent per year, two more reactors were planned for the Paks station, each a 1,000-MWe VVER from the Soviet Union; however those plans were cancelled in late 1990 because the government wished to examine other alternatives. Hungary now has begun anew by soliciting offers worldwide for new plant capacity. Negotiations appear to be most active with a consortium led by Electricité de France and PREAG of Germany, which has offered to supply two 900-MWe PWRs of French-German technology. The consortium would provide about 70 percent of the financing, and electricity exports, equivalent to half the plants' production, would be used to repay this construction loan.

Another alternative under serious consideration is an offer from AECL and Ontario Hydro to supply four, 450-MWe CANDU reactors. The Canadian government, AECL, and Ontario Hydro have been working closely with the Hungarians for over a year. The Canadian government already has indicated it likely would approve loans to Hungary for funding this project. Several other offers have also been received, including a proposal from Switzerland's ABB Atom, a joint proposal from Finland's Imatron Voima Oy (IVO) and Atomenergoexport of the former Soviet Union, and an offer from a consortium of Westinghouse (USA), Bechtel (USA), Ansaldo (Italy), and INITEC, ENSA, and ENUSA (Spain). Regardless of the type of plant or reactor supplier selected, Hungary's limited supply of hard currency will require financing the plants' construction through loans from the supplier, with repayment in the form of electricity exports.

Internally, Hungary restructured its governmental regulation of nuclear power. The country's Atomic Energy Commission (AEC) became an independent body effective January 1, 1991. The AEC is the country's nuclear regulatory agency and formerly had been supervised by the Ministry of Industry and Trade, which also supervised operations at the Paks station. Granting the Commission autonomy is a positive move, allowing more objective reviews and critiques of performance at Paks. These reviews, combined with current safety improvement programs from the International Atomic Energy Agency and the World Association of Nuclear Operators, and with the experience gained at IVO's VVERs in Finland, are helping safety efforts at Paks to rise quickly to international standards.

FUEL CYCLE DEVELOPMENTS

In February, MVMT reached an agreement with Atomenergoexport (AEE) for the purchase of fabricated fuel for use in Paks nuclear station. At that time, a major factor in the choice of AEE was that the Paks station's spent fuel would be taken by AEE for final disposal in the Soviet Union. The contract was to cover the entire operational life of the Paks units. MVMT sought competing Western offers, but no other offer contained a provision for the final disposal of spent fuel. In a separate contract, the Soviet Union agreed to purchase the yellowcake needed to produce the Paks fuel from Hungary's Mecsek mine at a price equivalent to world market prices.

The recent changes in the former Soviet Union, the high costs imposed by the Soviets for spent fuel disposal, as well as a desire to establish more independence in fuel services, led MVMT to alter its earlier position. MVMT decided at the end of 1991 not to send spent fuel back to the former Soviet Union, and instead to develop domestic interim storage. Hungary had already been looking at alternatives, and had solicited offers from several Western companies to submit feasibility studies on long-term spent fuel storage. Canada has sent experts to Hungary and is examining the

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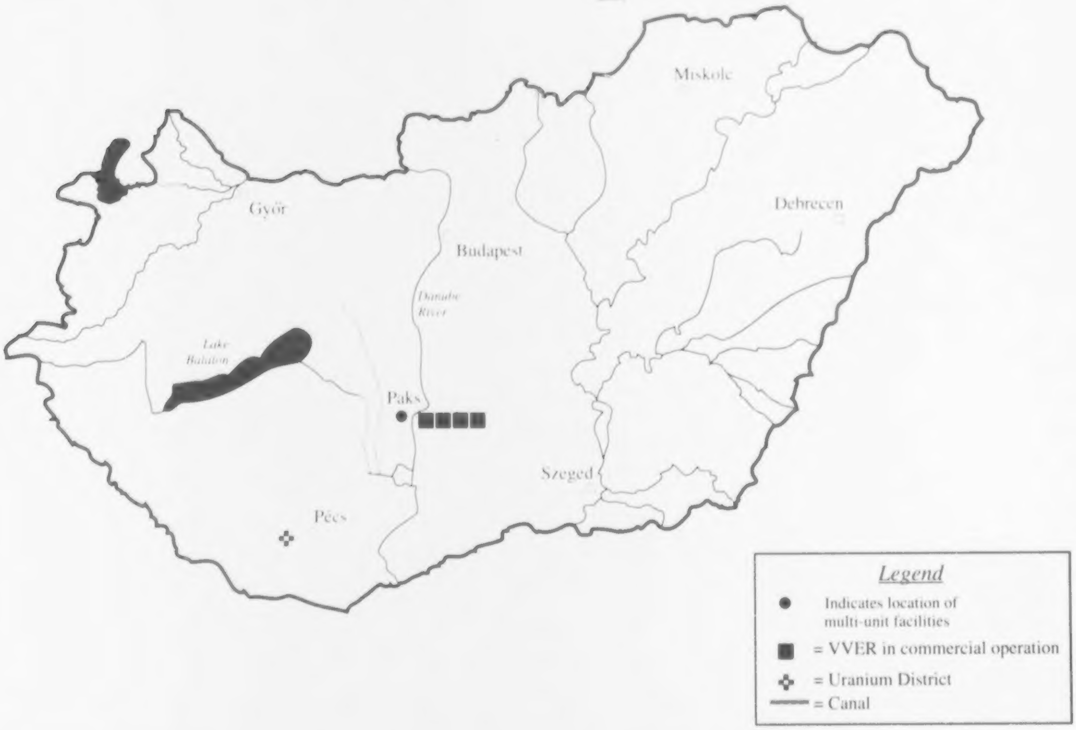
Figure 38
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES IN HUNGARY



feasibility of a potential waste storage site below the Pécs uranium mine, once it is shut down. Preliminary studies have indicated that a site below the Pécs mine could be geologically sound for a repository. MVMT likely will request formal bids for methods to deal with its spent fuel in the near future.

Uranium Production

Only one exploitable uranium deposit exists in Hungary. The Pécs uranium project is located in the southern part of the country on the western flank of the Mecsek Mountains (**Figure 38**). The mining project is operated by the state-owned Mecsek Ore Mining Company. In 1990, the Hungarian government had decided to shut down the mine by 1992 because of uneconomical operating costs. However, in mid-1991, the government reversed its decision and agreed to continue to subsidize production because the costs of subsidies were substantially less than the cost of worker retraining, unemployment compensation, and decommissioning of the site. Production is expected to continue at least through 1994.

Between 1956 and 1990, 49 million pounds equivalent U_3O_8 were produced from the Pécs project. Remaining reasonably assured resources (RAR) total 5.6 million pounds U_3O_8. Economically, only about 4 million pounds U_3O_8 of the RAR is recoverable at less than $30 per pound U_3O_8. Uranium ore is mined by conventional underground methods, and ore from the deposit is fully processed in the company's own mill located approximately 1.5 km from the mine. Production has ranged from 1.0 million pounds U_3O_8 per year to a peak of 1.8 million pounds, recently averaging about 1.3 million pounds annually.

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Table 34
NUCLEAR POWER UNITS IN HUNGARY

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Paks 1	MVMT [2]	415	VVER	1983	79	2,897
Paks 2	MVMT	425	VVER	1984	92	3,429
Paks 3	MVMT	435	VVER	1986	85	3,222
Paks 4	MVMT	435	VVER	1987	88	3,359
TOTAL		**1,710**		***(1991 Average:***	**86)**	**12,907**

Units Planned [3]

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	Percent Complete
Paks 5	MVMT	900	PWR	1998	planned
Paks 6	MVMT	900	PWR	2000	planned
TOTAL		**1,800**			

[1] COD = Commercial Operation Date (actual or expected)

[2] MVMT = Magyar Villamos Muvek Troszt (Hungarian Electricity Board)

[3] The two units are currently planned as PWRs to be built with the assistance of an EdF-led consortium. However, no final selection has yet been made, and a proposal for CANDU HWR units built with Canadian assistance is also under consideration, as well as proposals from several other groups.

ITALY

Italy has no operating nuclear power stations. The Trino and Caorso stations last generated power in 1987 before they were shut down permanently as a result of an anti-nuclear public referendum. The plants were kept mothballed until the Italian Parliament voted in June 1990 to decommission the plants. Ente Nazionale di Energia Elettrica (ENEL), Italy's national utility, began decommissioning activities for the plants this past year, including signing fuel reprocessing contracts with British Nuclear Fuels plc.

The 1987 referendum that closed the reactors expires in 1992. Italian institutions are continuing research and development on advanced light water reactor designs, although it is unlikely Italy will embrace nuclear power again soon. Nuclear proponents are formulating plans to have advanced reactor designs ready when the government elects to reconsider nuclear power's role in the country's energy strategy. Many experts were concerned that without the nuclear plants, Italy would soon face power shortages. However, ENEL received authorization in 1991 to build five new natural gas-fired power stations, which will help to alleviate potential power supply shortages. As a result, it is likely that no new nuclear plants will be commissioned until well past the year 2000.

LITHUANIA

When it became independent in 1991, Lithuania became the twenty-seventh country in the world to have nuclear power. This Baltic republic declared its independence from the Soviet Union on March 11, 1990, but was not recognized as independent until this past year.

Lithuania formally took possession of the world's largest nuclear power station at Ignalina on August 27, 1991. The Lithuanian Ministry of Energy officially became the owner of the two reactors, each a 1,380-MWe RBMK, but reached an agreement in September with the Soviet Ministry of Atomic Energy and Industry that allowed the now-Russian Ministry to retain its responsibility for the operation, safety, fuel, and equipment of the station. The station will remain in the Soviet inventory under Soviet IAEA safeguards, until Lithuania can sign, ratify, and enact the conditions of the Treaty on the Non-Proliferation of Nuclear Weapons.

Lithuania also signed an agreement with the Swedish Nuclear Power Inspectorate (SKI), in which SKI will assist Lithuania in establishing a nuclear regulatory agency and initiating an inspection program for its RBMK reactors.

Table 35
NUCLEAR POWER UNITS IN LITHUANIA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]
Ignalina 1	MAEI [2]	1,380	RBMK	1985
Ignalina 2	MAEI	1,380	RBMK	1989
TOTAL		**2,760**		

[1] COD = Commercial Operation Date
[2] MAEI = Ministry of Atomic Energy and Industry (of the former Soviet Union)

THE NETHERLANDS

The Netherland's two operating nuclear units, the 481-MWe Borssele pressurized water reactor and the 58-MWe Dodewaard boiling water reactor, achieved capacity factors of 65 and 82 percent, respectively, in 1991. These plants supplied about seven percent of Dutch electricity. The owner of the Borssele plant, NV Electriciteits-Produktiemaatschappij Zuid-Nederland (EPZ), approved a backfitting program in 1991 which will allow EPZ to extend plant operations until 2004. Operations at Dodewaard also are expected to be extended until 2004.

While a majority of the Dutch public still opposes expansion of the nuclear program, continued growth in electricity demand and increased concern regarding the threat of global warming convinced the Dutch government to announce plans to end an existing moratorium on nuclear development in 1994. No new projects are likely to be considered for several years, however, so it will be well into the next century before any new plants could be operating. Nevertheless, it will be difficult for the Netherlands to meet its ambitious emissions control targets without greater dependence on nuclear power.

The government approved construction of a nuclear waste facility to store spent fuel at the Borssele plant. The facility, to be completed in 1992, has twice the capacity required for existing plants.

EPZ continues to purchase its natural uranium from the spot market. Its enrichment needs are covered by a requirement contract with Urenco, which operates an enrichment plant at Almelo in The Netherlands. The Dutch have reprocessing contracts with Cogema.

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PORTUGAL

Uranium production in Portugal declined dramatically in 1991, falling from 290 thousand pounds equivalent U_3O_8 in 1990, to 70 thousand pounds in 1991. Previously, Empresa Nacional de Uranio (ENU), Portugal's sole uranium producer, extracted over 75 percent of its production from open-pit and underground mines near its Urgeirica production center in northern Portugal. ENU's reduced production now comes primarily from mine water recovery methods. However, ENU currently has no outlet for its production, as its long-term supply contract with Electricité de France expired in 1991.

Portugal has no domestic nuclear power program presently, and no development plans in that area. The country imports over 85 percent of its energy supply; the balance is generated from domestic hydroelectric and biomass plants. The country has made a concerted effort in recent years to restructure its energy sector, and its efforts have, thus far, been quite successful: a major program to introduce natural gas into the energy mix has been finalized; several state monopolies in the oil and gas industries have been dismantled; numerous private independent power producers are now operational and will contribute as much as ten percent of the country's electricity supply by 1993; Petrogal, the national oil company, has been prepared for privatization; and Electricidade de Portugal (EdP), the state utility, has been restructured for increased efficiency and competitiveness in the European market. EdP is now a public limited company, and will be broken into six divisions: a production company, a high-tension transmission company, and four regional distribution companies. EdP also finalized a tripartite electricity supply agreement in early 1991 with France and Spain that will provide 312 MWe of supply capacity per year for ten years beginning in 1994. This will be critical in meeting Portugal's forecast electricity demand growth of over five percent annually in the 1990s.

ROMANIA

After more than two years, construction began once again at the Cernavoda nuclear station in Romania. Construction at the five-unit CANDU station was stopped in 1989, pending verification and documentation of the work already completed. The suspension also allowed time for repairs and retrofits to bring the units up to Western standards.

In mid-1991, AECL of Canada and Ansaldo S.p.A. of Italy agreed to create a consortium that will complete Unit 1, a 620-MWe HWR. AECL will supply the nuclear steam supply systems, while Ansaldo will be involved in the remainder of the plant. The consortium has a contract worth approximately C$415 million with Romania's national utility, Regia Autonoma Nationala de Electricite (RENEL), for the reactor's completion.

The contract to finish the plant, which is currently 67-percent complete, was dependent upon approval of Canadian and Italian loans to finance the project. In the second half of 1991, loans of up to C$315 million were granted by Canada's Export Development Corporation and up to C$175 million by the Italian government. The loans will ensure completion of the plant, now scheduled for 1995, as well as enable RENEL to retain Canadian expertise for training, engineering, and operational support after the plant is commissioned.

The future of the other four units is less certain, although the Romanian government has designated completion of the station as a priority, to address the country's severe energy shortages. Nevertheless, it is unlikely any other units will be complete until the late 1990s.

Romania has three uranium production areas: the Brasov area in central Romania, the Bistritei Mountains in the north, and the Almas Mountains in the southwest. Domestic production capacity has been estimated at more than two million pounds equivalent U_3O_8 annually. In addition, Romania can produce UO_2 powder and, under license from Canada, plans to produce its own fuel assemblies for the CANDU reactors.

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SLOVENIA

The Republic of Slovenia declared independence from Yugoslavia on November 8, 1991, and was first recognized as an independent state on January 15, 1992. Slovenia is the only republic in the former country of Yugoslavia with production centers for uranium and nuclear power generation.

The utility consortium Nuklearna Elektrarna Krško (NEK), owned equally by the governments of Slovenia and Croatia, operates a 632-MWe pressurized water reactor near the Croatian border in Krško, Slovenia (**Figure 39**). The unit generated over 4,718 GWh and achieved a capacity factor of 85 percent during 1991, despite a 17-day shutdown and a subsequent mandate to cut operating rates for safety reasons. The shutdown occurred in response to an airplane that buzzed the plant early in the Yugoslavian civil war. Krško, protected by a nearby military installation, was never under attack during the war, despite fighting as close as 15 kilometers from the plant.

Although the war destroyed approximately 50 percent of Croatia's industrial production capacity, damage to conventional power plants and transmission lines was even worse. As a result, electricity generated by Krško has increased in importance to both republics and will influence discussions regarding the political acceptability of nuclear power in Croatia and Slovenia over the next year. Krško provided 25 percent of Slovenia's and 19 percent of Croatia's total electricity generation during 1991. The station's share of total generation is expected to remain near these levels in 1992, even though the plant has two major modifications planned for its upcoming annual outage: replacement of its condenser tubes and the plant information system.

Slovenia's sole uranium mine and mill, Zirovski Vrh, ceased production in 1990. The last delivery of uranium from the facility was made at the end of April 1991. The project operator, Rudnik Urana Zirovski Vrh, is a division of the Slovenian government, and elected to stop production due to high costs and environmental concerns. To replace the loss of domestic production, NEK has contracted on the long-term concentrates market. Its enrichment requirements are purchased from the US Department of Energy. All spent fuel is stored on site.

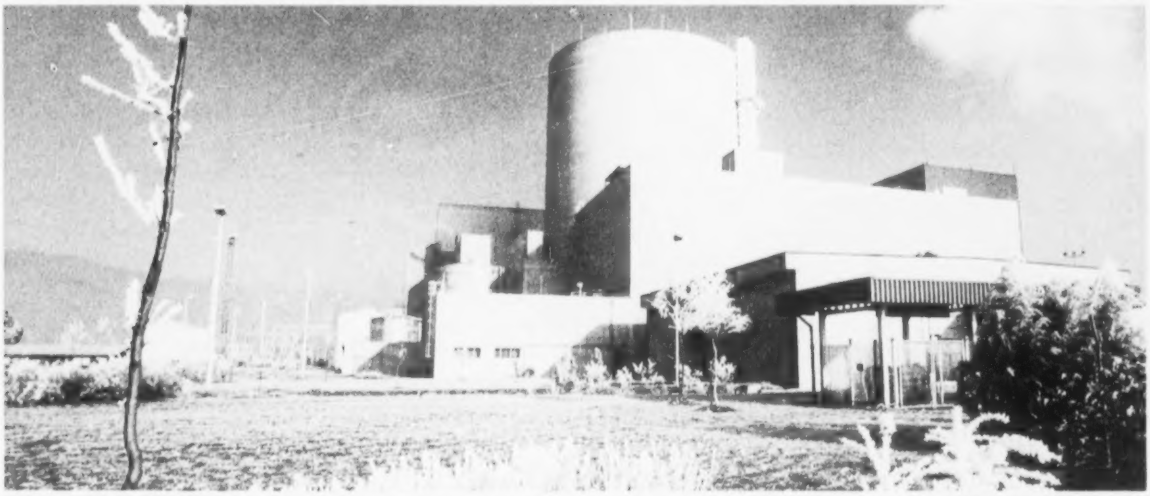

Figure 39 — Krško Nuclear Power Station. *(Photo courtesy of NEK)*

SPAIN

Spain had nine nuclear reactors in operation during 1991. The nine operating units achieved an average capacity factor of 85 percent and produced 53,265 GWh (**Table 36**). Notably, two reactors, Almaraz 1 and Garona (**Figure 40**), each achieved a capacity factor exceeding 95 percent during the year, ranking them in the top fifteen in the world in that category.

The Spanish government has stated that it will set up a holding company to manage Spain's nuclear assets. And, in a further attempt to improve the competitiveness of its electricity sector in Europe, the government has pushed for consolidation within the industry. The rationale behind consolidation is that once larger utilities are created from numerous smaller ones, separating electricity generating facilities from electricity distribution systems will be easier. Division of the generation and distribution portions of the utilities, perhaps involving redistribution of assets among the entities, could be accomplished within a smaller number of larger utilities, making the power producers more competitive.

Spain's new national energy plan (PEN) released in 1991, does not permit the operation of any new nuclear plants before the year 2000, and instead, will depend primarily upon natural gas to meet the country's growing electricity demand, which is forecast to be 3.5 percent annually. Although there was pressure to resume construction of two partially-complete boiling water reactors at Valdecabelleros, the units will remain indefinitely deferred. Spain's new PEN follows the direction of the 1984 national energy plan, leaving the Valdecabelleros units to be maintained for possible resumption of construction.

Under the new PEN, nuclear power's share of Spain's total installed capacity falls from about 17 percent in 1990, to approximately 14 percent by the end of the century. The contribution made by natural gas is forecast to more than quadruple to almost 13 percent, with industrial cogeneration expected to make up about 3,900 MW of new electric generating capacity.

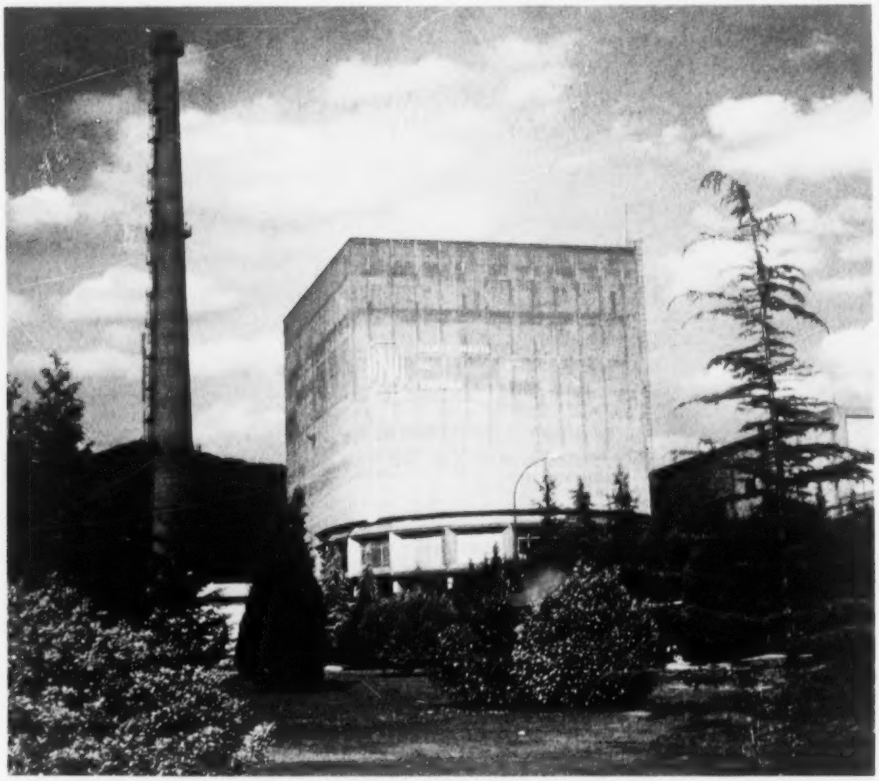

Figure 40 — Garona Nuclear Power Station. This 440-MWe BWR achieved a 96-percent capacity factor in 1991. *(Photo courtesy of ENUSA)*

URANIUM SUPPLY

Empresa Nacional del Uranio SA (ENUSA) began a major expansion of its uranium concentrates production plant at Saelices el Chico, near Ciudad Rodrigo, in 1990 (**Figure 41**). The new facility, which is planned for operation in 1993, will have a nominal production capacity of 2.1 million pounds equivalent U_3O_8 per year. Following Spain's strategy for long-term uranium procurement, ENUSA will be able to supply the majority of the country's uranium requirements through domestic production. In addition to the plant at Saelices el Chico, ENUSA is an equity holder in Compagnie Minière d'Akouta (COMINAK), owner of the Akouta mine in Niger.

ENUSA has several long-term conversion contracts and purchases most of its enrichment requirements from the US Department of Energy and Techsnabexport. ENUSA operates its own fuel fabrication facility in northern Spain, which produces BWR and PWR fuel elements under General Electric and Westinghouse licenses, respectively. During 1991, ENUSA joined with Westinghouse and British Nuclear Fuels plc. to form the European Fuel Group (EFG). EFG is a cooperative agreement among the three companies in which they will pool their resources for the design, marketing, and manufacture of PWR fuel for the European market. Although contracts will be negotiated separately by each of the companies, the work will be assigned to the appropriate member of the EFG.

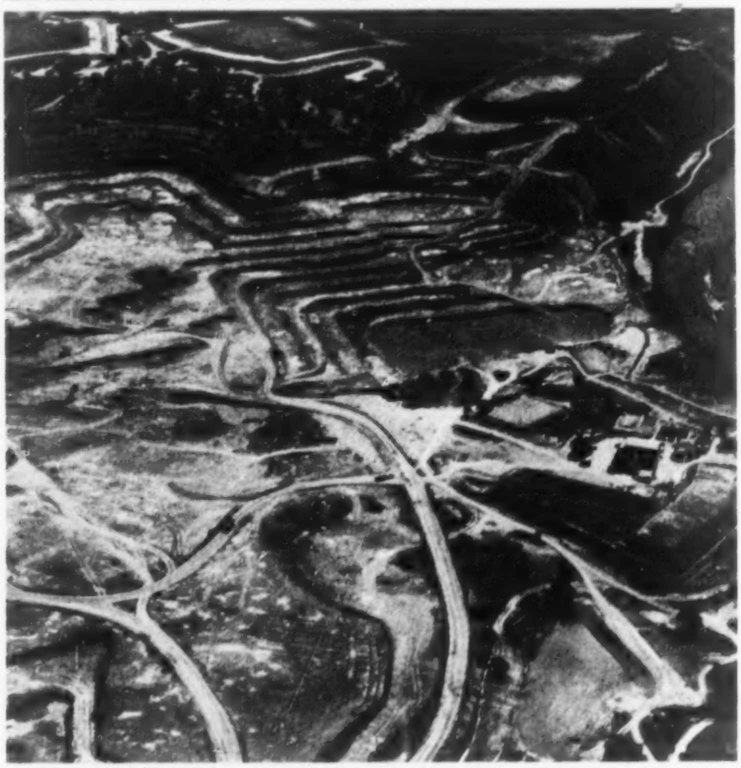

Figure 41 — Saelices el Chico Uranium Production Project.
(Photo courtesy of ENUSA)

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Figure 42
NUCLEAR POWER UNITS AND URANIUM PRODUCTION AREAS IN SPAIN

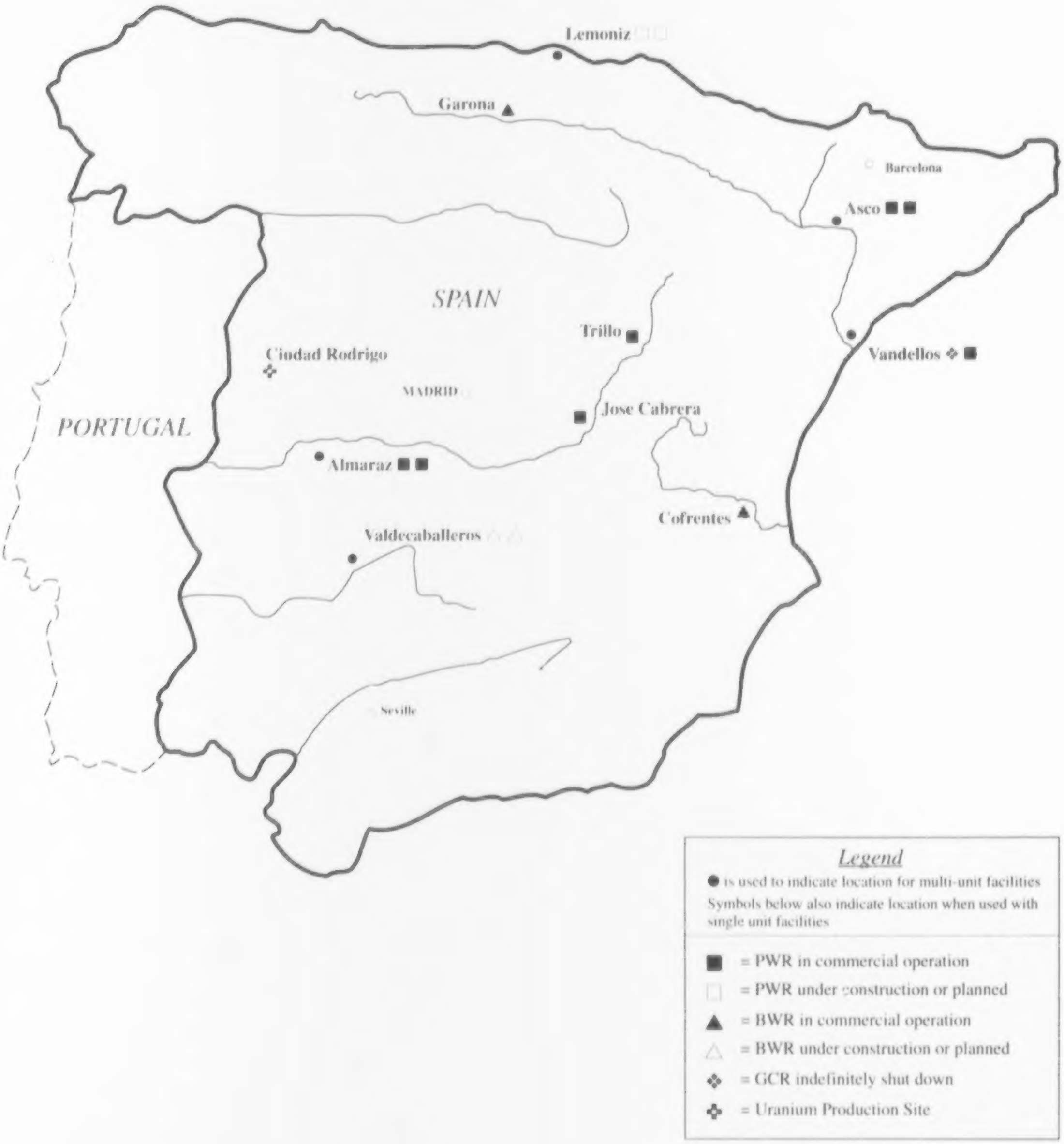
Lemoniz □□
Garona ▲
Barcelona
Asco ■■
SPAIN
Trillo ■
Vandellos ✥ ■
Ciudad Rodrigo ✥
MADRID
PORTUGAL
Jose Cabrera ■
Almaraz ■■
Cofrentes ▲
Valdecaballeros △△
Seville
Legend
● is used to indicate location for multi-unit facilities
Symbols below also indicate location when used with single unit facilities
■ = PWR in commercial operation
□ = PWR under construction or planned
▲ = BWR in commercial operation
△ = BWR under construction or planned
✥ = GCR indefinitely shut down
✥ = Uranium Production Site

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Table 36
NUCLEAR POWER UNITS IN SPAIN

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Almaraz 1	ENUSA [2]	895	PWR	1981	95	7,470
Almaraz 2	ENUSA	895	PWR	1984	86	6,711
Asco 1	ENUSA	930	PWR	1983	83	6,778
Asco 2	ENUSA	930	PWR	1986	83	6,753
Cofrentes	ENUSA	939	BWR	1985	85	6,956
Garona	ENUSA	440	BWR	1971	96	3,684
Jose Cabrera [3]	ENUSA	153	PWR	1969	79	1,056
Trillo 1	ENUSA	990	PWR	1988	77	6,655
Vandellos 2	ENUSA	943	PWR	1988	87	7,202
TOTAL		**7,115**		***(1991 Average:***	**85)**	**53,265**

Units Deferred

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	Percent Complete [4]
Valdecaballeros 1	ENUSA	930	BWR	71
Valdecaballeros 2	ENUSA	975	BWR	58
Lemoniz 1	Iberduero	900	PWR	97
Lemoniz 2	Iberduero	900	PWR	57
TOTAL		**3,705**		

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[1] COD = Commercial Operation Date

[2] ENUSA = Empresa Nacional del Uranio SA

[3] Also known as Zorita

[4] Source: *Nuclear News*

SWEDEN

Sweden's nuclear power reactors operated very well in 1991, generating more electricity than in any previous year. The twelve reactors, located at four stations, generated more than 73 thousand GWh in 1991, with an average capacity factor of 85 percent (**Table 37**). Oskarshamn 3, a 1,065-MWe BWR, achieved a capacity factor of 95 percent during the year (**Figure 43**), and all but two of Sweden's reactors had capacity factors exceeding 80 percent. The record power generation can be attributed to a power uprating completed at several plants during 1989 and 1990, and also to a lower availability of hydroelectric power during 1991, which caused the nuclear plants to run at full load during much of the year. Nuclear power generated 51.6 percent of all electricity produced in Sweden.

Following a 1980 referendum, the Swedish government had decided to phase-out nuclear power completely by 2010, with the first plants scheduled for shutdown in 1995. In addition, other decisions essentially prohibited hydroelectric expansion, and also limited CO_2 emissions, thus virtually eliminating any economic energy replacements. The recognition of the important role that nuclear energy plays in the country's economy, coupled with a lack of economic electricity-generating alternatives, led the government to reconsider its nuclear phase-out plans.

On January 15, 1991, Sweden's three major political parties—Social Democrat, Liberal, and Center—announced that they had reached an agreement on a revised plan for phasing out nuclear power in the country. The first plants will not be decommissioned beginning in 1995 as originally scheduled. Instead, the decommissioning will be postponed

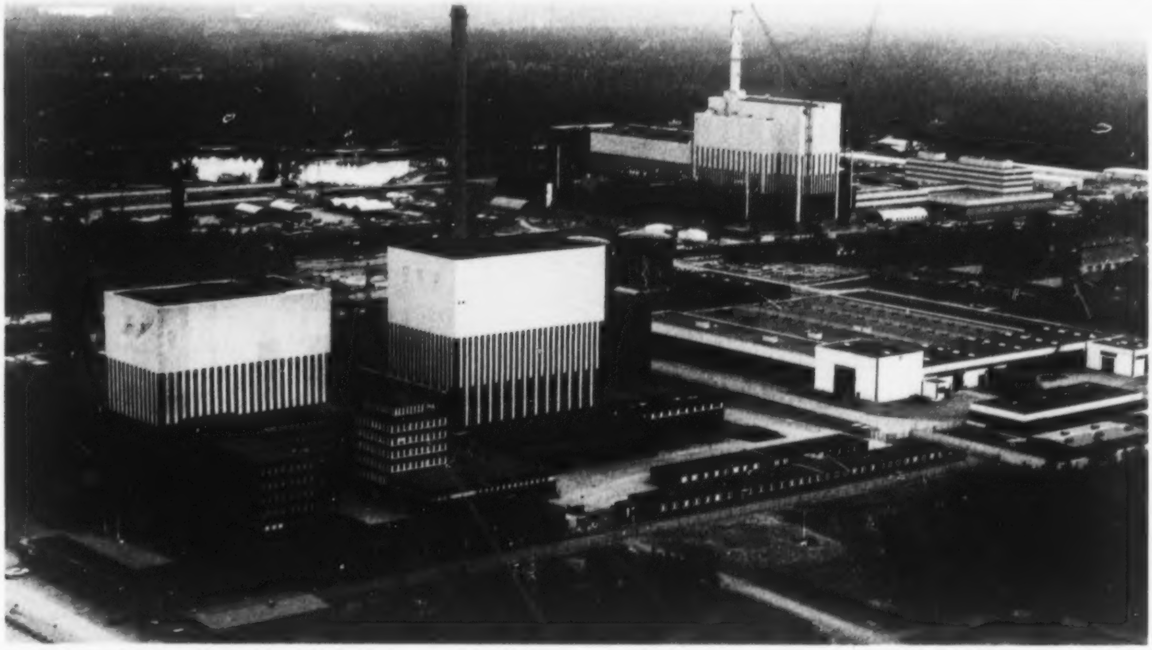

Figure 43 — Oskarshamn Nuclear Power Station. Unit 3, a 1,065-MWe BWR, ranked in the top twenty reactors in the world in 1991, generating almost 9,000 GWh. *(Photo courtesy of OKG)*

until after the turn of the century. The 2010 date for complete nuclear phase-out remains in place, although only if alternative power supplies are available. The agreement also calls for an investment of nearly US$1 billion in development of renewable energy sources and conservation measures. Additionally, the new plan will change the policy on CO_2 emissions, calling for a strategy to stabilize the level of global-warming emissions by the year 2000.

Following their victory in the September elections, the new conservative coalition government announced in November its intention to privatize Vattenfall (Swedish State Power Board). Vattenfall, which produces about half the country's electricity, became a 100-percent government-owned shareholding company in January 1992. The Swedish government has not determined exactly how and when Vattenfall will be sold to the public, although tentative plans indicate that the government wishes to sell Vattenfall by 1993. The government also plans to open access to the Swedish power grid.

Swedish nuclear utilities purchase most of their uranium through long-term contracts and some spot purchases, usually with Canadian and Australian producers. Enrichment requirements are met by Eurodif, Urenco, DOE, and Techsnabexport.

Sweden has progressed gradually on its high-level waste disposal plans. Near the Oskarshamn nuclear power station, the country has begun construction on a underground laboratory to study that location as a possible disposal site in the granite base rock. Currently, an interim storage facility near the laboratory site is being used to store the country's spent fuel.

Table 37
NUCLEAR POWER UNITS IN SWEDEN

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Barsebäck 1	Sydkraft AB	600	BWR	1975	85	4,471
Barsebäck 2	Sydkraft AB	600	BWR	1977	87	4,577
Forsmark 1	Vattenfall [2]	967	BWR	1980	88	7,419
Forsmark 2	Vattenfall	970	BWR	1981	83	7,086
Forsmark 3	Vattenfall	1,150	BWR	1985	85	8,575
Oskarshamn 1	OKG [3]	442	BWR	1972	86	3,334
Oskarshamn 2	OKG	605	BWR	1975	77	4,083
Oskarshamn 3	OKG	1,065	BWR	1985	95	8,886
Ringhals 1	Vattenfall	795	BWR	1976	80	5,578
Ringhals 2	Vattenfall	800	PWR	1975	89	6,236
Ringhals 3	Vattenfall	915	PWR	1981	74	5,947
Ringhals 4	Vattenfall	915	PWR	1983	87	6,961
TOTAL		**9,824**		*(1991 Average:*	**85)**	**73,151**

[1] COD = Commercial Operation Date

[2] Vattenfall is the Swedish State Power Board. Forsmark Kraftsgrupp AB (FKA) is the owner of the Forsmark and Ringhals stations, while Vattenfall is the operator and fuel purchaser. Vattenfall owns 74.5 percent of FKA.

[3] OKG = OKG Aktiebolag

SWITZERLAND

Switzerland's five installed nuclear power units each operated very successfully during the year. Overall, the plants averaged an 84 percent capacity factor in 1991 (**Table 38**), supplying 39 percent of the country's total electricity generation. The balance of the country's domestic generation is provided by hydropower. Additional power requirements are imported from France, both from nuclear power plants in which the Swiss have an ownership interest, and from other contracts that are based on the French nuclear power plants.

Although there currently is a moratorium on the construction of new nuclear power plants in Switzerland, the nuclear option is still open for consideration at the end of this decade. In the meantime, a 500-kW solar power plant, the largest in Europe, has been built on Mont Soleil, in the distribution area of Bernische Kraftwerke AG (BKW), to demonstrate the operation and financial considerations of solar energy. The energy cost of power from this unit is estimated at about one Swiss Franc per kWh.

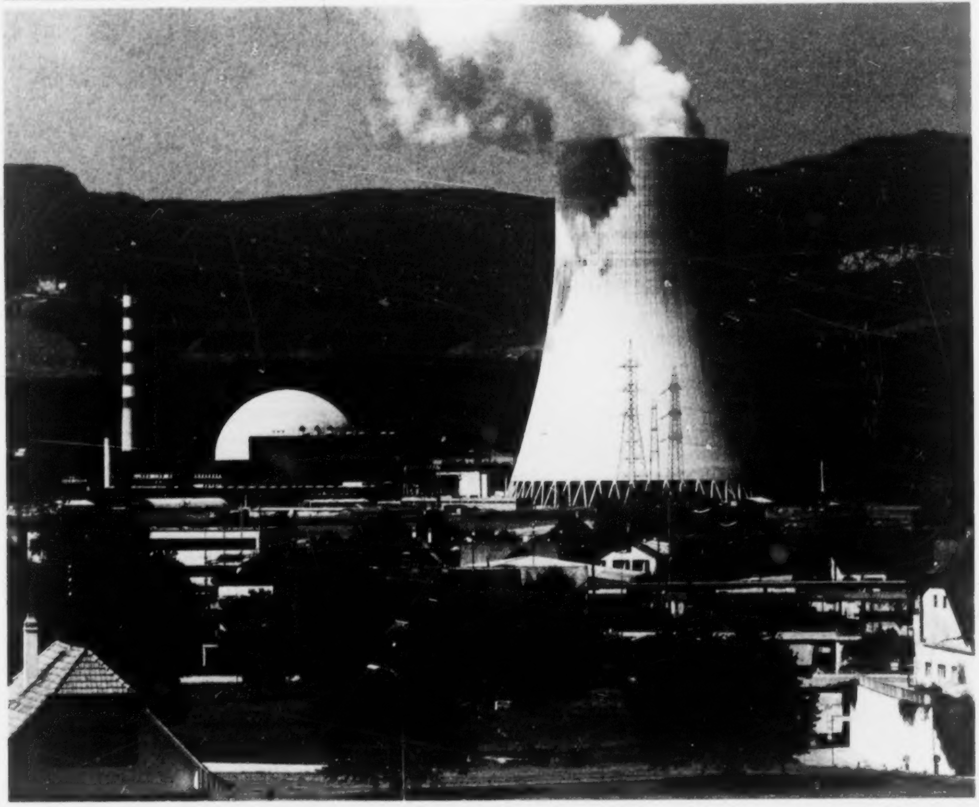

Figure 44 — Gösgen Nuclear Power Plant. (*Photo courtesy of KKG*)

BKW anticipates receiving its new operating license late in 1992, and in conjunction with the license, approval for a 10-percent increase in the power rating of its Mühleberg nuclear power plant. Nordostschweizerische Kraftwerk AG continued work to upgrade certain design safety systems on its 350-MWe Beznau reactors.

Siting of depositories for storing nuclear wastes remained a controversial issue in 1991, but it is anticipated that federal authorities will approve construction of an intermediate storage facility at the Paul Scherrer Institute by the end of 1992. Although local authorities provided their endorsement of the project in late 1990, further public hearings are scheduled for February 1992. Subject to receiving final approval to proceed by the end of this year, the facility is planned to begin receiving nuclear waste in 1996.

Table 38
NUCLEAR POWER UNITS IN SWITZERLAND

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Beznau 1	NOK[2]	350	PWR	1969	81	2,495
Beznau 2	NOK	350	PWR	1971	85	2,618
Gösgen	KKG[3]	940	PWR	1979	86	7,140
Leibstadt	KKL[4]	990	BWR	1984	81	7,020
Mühleberg	BKW[5]	322	BWR	1972	85	2,413
TOTAL		**2,952**		*(1991 Average:*	**84)**	**21,686**

[1] COD = Commercial Operation Date
[2] NOK = Nordostschweizerische Kraftwerk AG
[3] KKG = Kernkraftwerk Gösgen-Däniken AG
[4] KKL = Kernkraftwerk Liebstadt AG
[5] BKW = Bernische Kraftwerk AG

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UNITED KINGDOM

The United Kingdom's 36 operating reactors achieved a 67 percent capacity factor in 1991 (**Table 39**). Nuclear power provided almost 21 percent of the electricity generated in the UK in 1991, similar to its share in 1990. The advanced gas reactors in the UK continued to show improved performance during 1991. Hunterston B2 reached a landmark in January, when it generated its 50-billionth kWh of electricity, the first advanced gas reactor in Britain to achieve this record.

Nuclear Electric's 1,175-MWe pressurized water reactor under construction at Sizewell on the Suffolk coast, achieved good progress in 1991 (**Figure 45**). At year end, construction was eight months ahead of the 72-month schedule and within the revised budget, following the cancellation of the follow-on PWR program. The first fuel core is expected to be loaded on schedule, sometime before the end of 1993. In other reactor developments, the Dounreay fast breeder reactor was decommissioned in early 1991 and did not operate during the year.

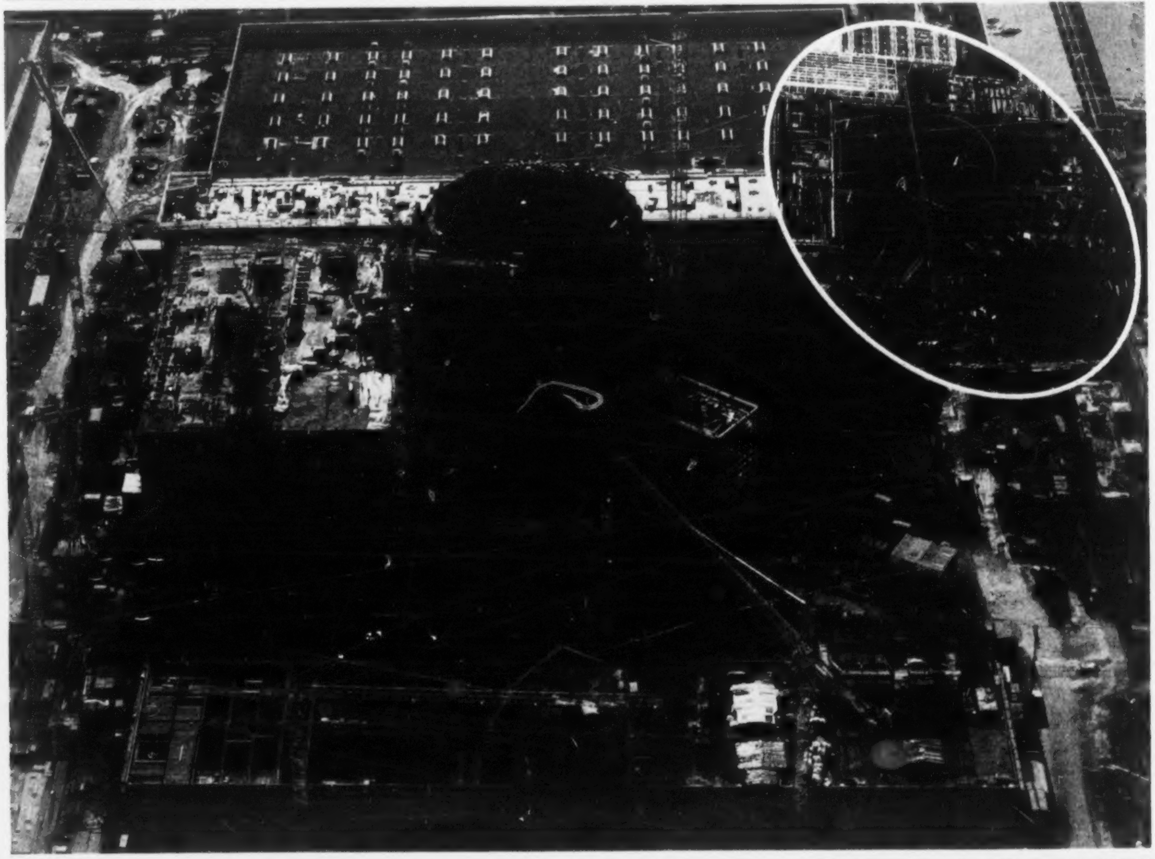

Figure 45 — Sizewell B Nuclear Power Plant under construction. Progress on this 1,175-MWE PWR is shown by comparing with the inset photo of a year ago—note the vessel dome on the ground in front of the reactor vessel. (*Photo courtesy of Nuclear Electric*)

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Table 39
NUCLEAR POWER STATIONS IN THE UNITED KINGDOM

Units/Stations In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Bradwell 1	Nuclear Electric	123	GCR	1962	74	797
Bradwell 2	Nuclear Electric	123	GCR	1962	69	746
Calder Hall 1, 2, 3, 4	BNFL [2]	50 ea.	GCR	1956-59	86	1,516
Chapel Cross 1, 2, 3, 4	BNFL	48 ea.	GCR	1959-60	90	1,508
Dounreay	UKAEA [3]	250	LMFBR	1976	—	784
Dungeness A1	Nuclear Electric	212	GCR	1965	76	1,419
Dungeness A2	Nuclear Electric	212	GCR	1965	83	1,546
Dungeness B1	Nuclear Electric	360	AGR	1985	91	2,880
Dungeness B2	Nuclear Electric	360	AGR	1989	50	1,589
Hartlepool A1	Nuclear Electric	420	AGR	1987	84	3,085
Hartlepool A2	Nuclear Electric	420	AGR	1987	52	1,930
Heysham A1	Nuclear Electric	470	AGR	1987	95	3,909
Heysham A2	Nuclear Electric	420	AGR	1987	73	2,694
Heysham B1	Nuclear Electric	615	AGR	1988	28	1,510
Heysham B2	Nuclear Electric	615	AGR	1989	47	2,529
Hinkley Point 1	Nuclear Electric	235	GCR	1965	57	1,177
Hinkley Point 2	Nuclear Electric	235	GCR	1965	83	1,703
Hinkley Point B1	Nuclear Electric	560	AGR	1978	95	4,681
Hinkley Point B2	Nuclear Electric	560	AGR	1976	49	2,395
Hunterston B1	Scottish Nuclear Ltd.	575	AGR	1976	41	2,077
Hunterston B2	Scottish Nuclear Ltd.	575	AGR	1977	95	4,793
Oldbury 1	Nuclear Electric	217	GCR	1967	64	1,220
Oldbury 2	Nuclear Electric	217	GCR	1968	91	1,728
Sizewell A1	Nuclear Electric	210	GCR	1966	79	1,456
Sizewell A2	Nuclear Electric	210	GCR	1966	93	1,714
Torness Point A1	Scottish Nuclear Ltd.	625	AGR	1988	47	2,581
Torness Point A2	Scottish Nuclear Ltd.	625	AGR	1989	49	2,699
Trawsfynydd 1	Nuclear Electric	195	GCR	1965	10	170
Trawsfynydd 2	Nuclear Electric	195	GCR	1965	10	164
Wylfa 1	Nuclear Electric	420	GCR	1971	101	3,706
Wylfa 2	Nuclear Electric	420	GCR	1972	107	3,955
TOTAL		**11,066**		***(1991 Average:***	**67)** [4]	**64,661**

[1] COD = Commercial Operation Date

[2] BNFL = British Nuclear Fuels plc.

[3] UKAEA=United Kingdom Atomic Energy Authority

[4] Average does not include those units that entered commercial operation or were retired during 1991.

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Table 39
NUCLEAR POWER STATIONS IN THE UNITED KINGDOM
(continued)

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	Percent Complete[2]
Sizewell B1	Nuclear Electric	1,175	PWR	1994	60

[1] COD = Commercial Operation Date (expected)
[2] Source: *Nuclear News*

Construction of additional nuclear plants in the UK, beyond Sizewell B, was suspended by the present government in November 1989, pending a major government review in 1994 regarding the future of nuclear power in the UK. A general election is scheduled for April 9, 1992 and it is a matter of speculation whether the succeeding government will retain this review as part of its policy.

The world's first industrial scale nuclear power station, Calder Hall, celebrated 35 years of operation in 1991. Nuclear Electric's Magnox stations are currently undergoing long-term safety reviews under which all aspects of the plant, its operation, and control systems, are examined. Subject to these reviews, and any resulting work being completed to the satisfaction of the Nuclear Installations Inspectorate, approval is expected for extension beyond the 30-year life currently assumed. During 1991, the lives of Nuclear Electric's AGRs at Hinkley Point B and Heysham 2 were extended from 25 to 30 years. The lives of the other AGRs in the UK currently remain at 25 years.

In March 1991, the British Civil Uranium Procurement Directorate and Organization, which formerly had been responsible for uranium procurement for the UK nuclear electricity generating companies, was disbanded. Nuclear Electric, Scottish Nuclear, and British Nuclear Fuels plc (BNFL) are now responsible for their own individual uranium procurement arrangements. However, a decision to assign the current uranium supply contracts with US and Australian companies to the individual companies has not yet been made. The UK utilities sold their uranium property interests in Australia during 1991, but continue to hold properties in Canada and the USA (including the Highland uranium mine).

In September, Nuclear Electric and BNFL formally agreed to a £13 billion (US$22billion) deal in which BNFL will provide fuel fabrication, spent fuel reprocessing, waste management, and decommissioning services to Nuclear Electric. The 15-year agreement is one of the largest ever signed worldwide.

Scottish Nuclear has begun exploring alternatives to spent fuel reprocessing, since factors which previously supported reprocessing as an economic option have changed. The appropriate government approvals to allow the utility to construct a dry storage facility are now being sought. In early 1992, Scottish Nuclear reached settlement with BNFL in which SNL will no longer reprocess its spent fuel at BNFL, but will investigate long-term storage options.

United Kingdom Nirex Ltd., the company responsible for developing a deep disposal facility for low-level and intermediate-level radioactive waste arising in the UK, announced that it is concentrating its investigation work at Sellafield. Intensive investigation over the last two years indicates that the geologies at either Sellafield or Dounreay could be suitable for the safe, underground disposal of radioactive waste. The investigations also included studies on environmental impact, social impact, transport infrastructure and other issues. Transportation is a major consideration, and was an important factor in the choice of Sellafield as the preferred site. Some 60 percent of the waste destined for the repository is generated from BNFL operations at the Sellafield site.

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Depending on continued good results from the geological investigations and a detailed environmental impact assessment, Nirex expects to submit a planning application in late 1992. If approved, the £1.25 million repository would open in 2005 and have an expected lifetime of 50 years. **Figure 46** shows an illustration of the proposed repository.

The latest stage of BNFL's £2 million waste management program at Sellafield was completed by the official opening of the Magnox Encapsulation Plant. The plant will process solid, intermediate-level radioactive waste, packaging it into a convenient form for handling, storage and eventual disposal in the repository.

Overseas, the state-owned Spanish company ENUSA, Westinghouse, and BNFL announced the creation of the European Fuel Group to design, market, and manufacture PWR nuclear fuel. In addition, the group will offer mixed oxide and reprocessed uranium fuel fabrication capability utilizing BNFL plants.

In late November, the UK Government also signed an agreement with the Republic of South Korea to expand and strengthen cooperation in the nuclear energy field. The agreement provides for the two-way transfer of nuclear material, equipment, and technology between both countries.

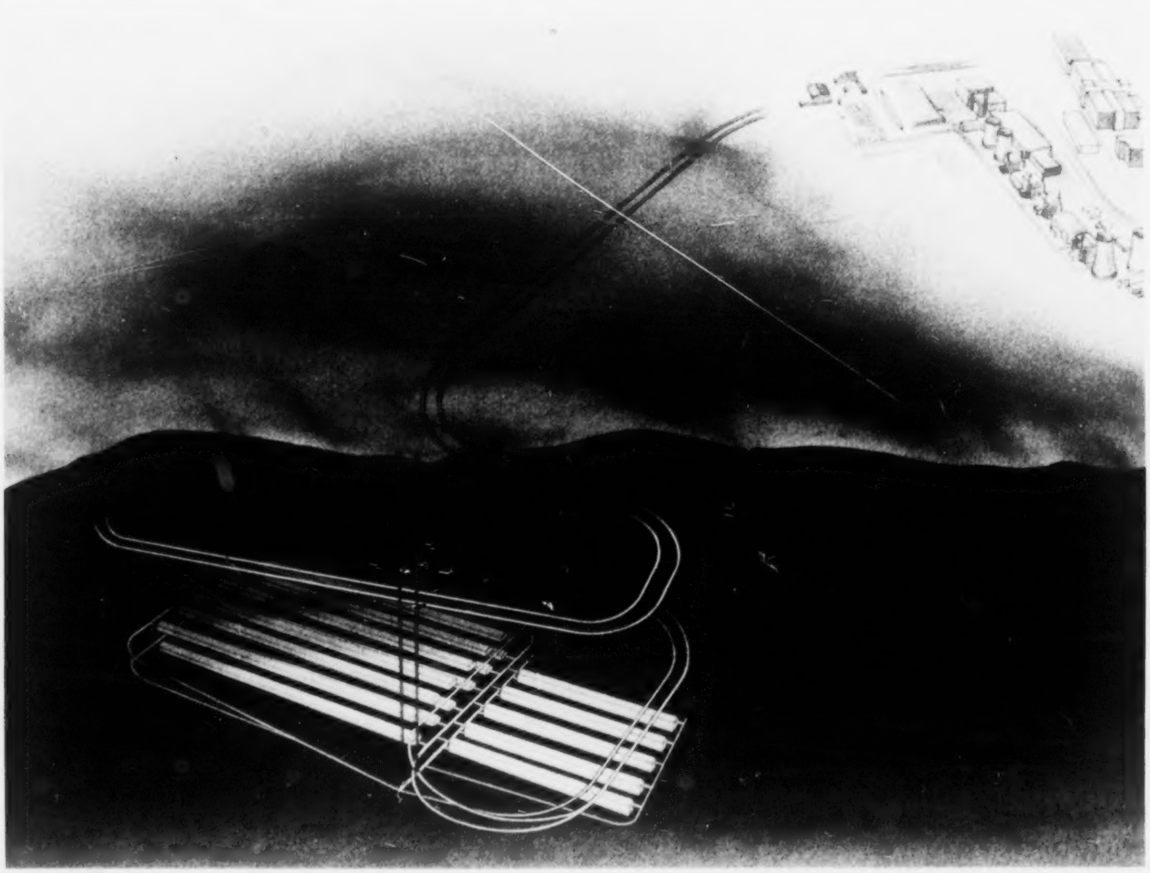

Figure 46 — Proposed Underground Nirex Nuclear Fuel Repository. *(Photo courtesy of UK Nirex, Ltd.)*

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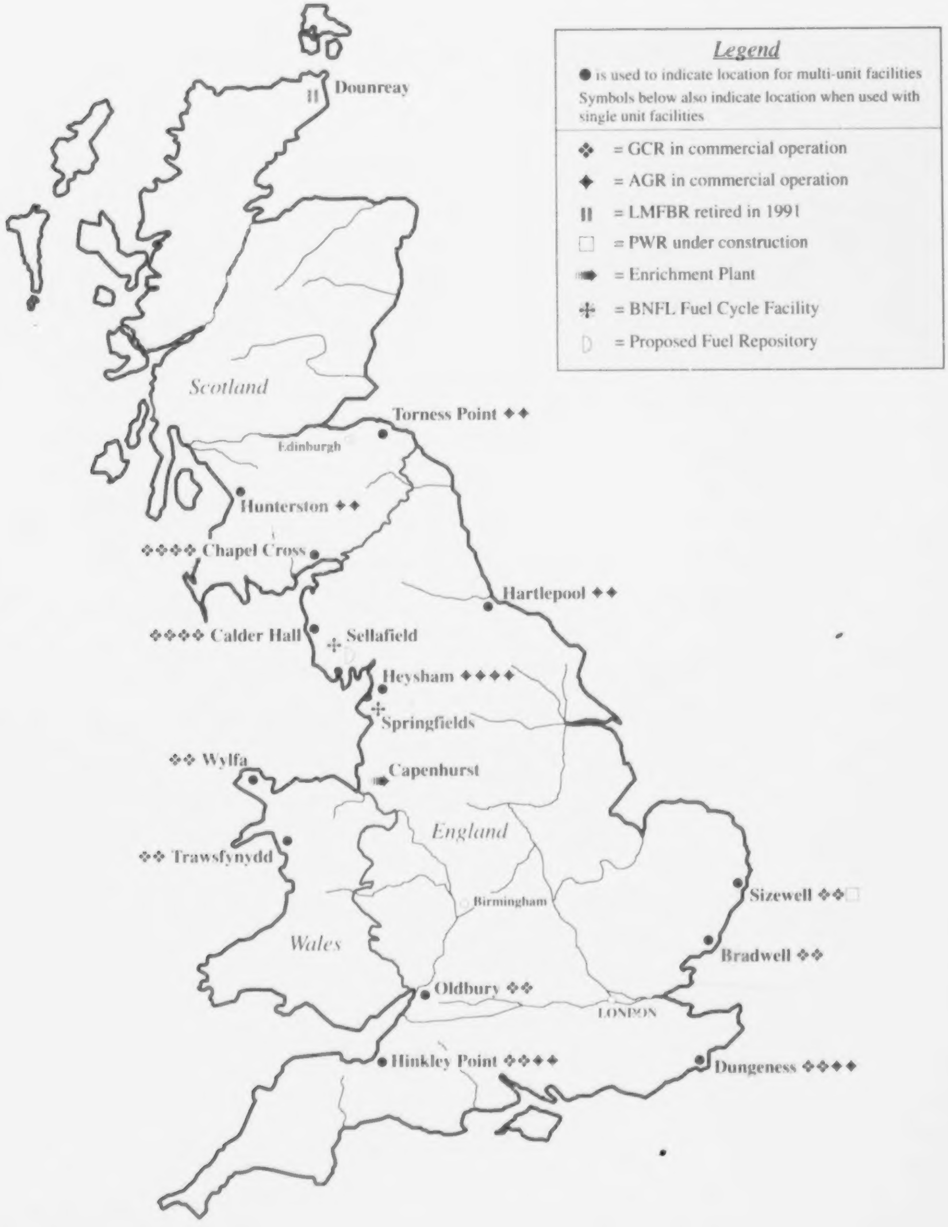
Figure 47

NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES IN THE UNITED KINGDOM


Legend
● is used to indicate location for multi-unit facilities
Symbols below also indicate location when used with single unit facilities
❖ = GCR in commercial operation
◆ = AGR in commercial operation
‖ = LMFBR retired in 1991
☐ = PWR under construction
➡ = Enrichment Plant
✣ = BNFL Fuel Cycle Facility
D = Proposed Fuel Repository
Dounreay
Scotland
Torness Point ◆◆
Edinburgh
Hunterston ◆◆
❖❖❖❖ Chapel Cross
Hartlepool ◆◆
❖❖❖❖ Calder Hall
Sellafield
Heysham ◆◆◆◆
Springfields
❖❖ Wylfa
Capenhurst
England
❖❖ Trawsfynydd
Sizewell ❖❖☐
Birmingham
Wales
Bradwell ❖❖
Oldbury ❖❖
LONDON
Hinkley Point ❖❖◆◆
Dungeness ❖❖◆◆

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NORTH AMERICA

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CANADA

Canada remained the world's leading uranium producer and also continued to develop its nuclear power program in 1991. The country produced 21.3 million pounds U_3O_8 during the year, down seven percent from 1990, but still significantly more than any other western country. Nuclear power remained an important contributor to the nation's energy mix, particularly in Ontario. As a whole, nuclear power contributes roughly 15 percent of Canada's total yearly electricity generation. Despite the challenges presented by an anti-nuclear provincial government elected in 1990, Ontario Hydro started up Darlington 1, solved some operational problems at Unit 2, and are nearing completion of Darlington 3 and 4 for operation in 1992 and 1993.

NUCLEAR DEVELOPMENTS

Ontario Hydro added Darlington 1 to its system in 1991, although the unit officially will not enter commercial operation until 1992. Total installed nuclear capacity in Canada now equals 13,993 MWe (net) in 20 reactors located at seven stations (**Table 40**). Two additional units, Darlington 3 and 4, remain under construction, with commercial operation scheduled for 1992 and 1993, respectively. The eight-reactor Bruce Station was the world's leading producer of nuclear-generated electricity during 1991, having generated 45.6 million megawatt hours (**Figure 48**). New Brunswick Power's Point Lepreau 1 plant continued to operate very well, achieving a 98 percent

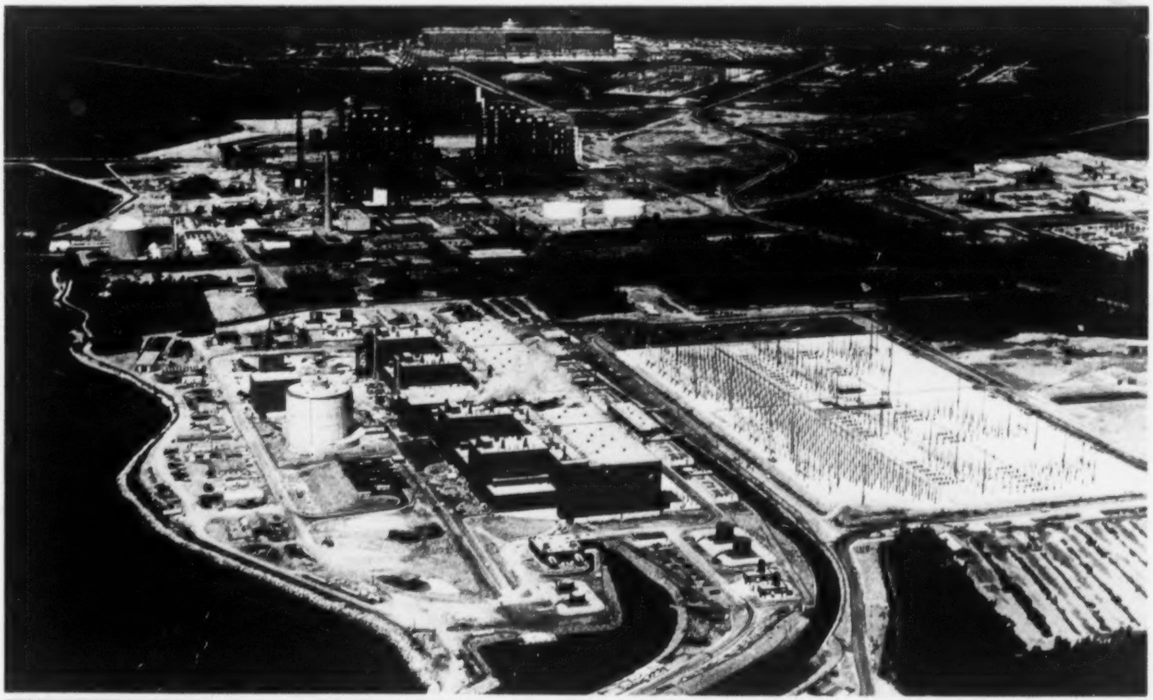

Figure 48 — Bruce Nuclear Power Station. The Bruce B complex is in the foreground, with the Bruce A complex in the far background, and the heavy water plants between the two complexes. *(Photo courtesy of Ontario Hydro)*

Table 40
NUCLEAR POWER UNITS IN CANADA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Bruce 1 'A'[2]	Ontario Hydro	848	HWR	1977	33	2,424
Bruce 2 'A'	Ontario Hydro	848	HWR	1977	61	4,516
Bruce 3 'A'	Ontario Hydro	848	HWR	1978	83	6,151
Bruce 4 'A'	Ontario Hydro	848	HWR	1979	81	5,982
Bruce 5 'B'	Ontario Hydro	860	HWR	1985	90	6,790
Bruce 6 'B'	Ontario Hydro	860	HWR	1984	93	7,033
Bruce 7 'B'	Ontario Hydro	860	HWR	1986	76	5,752
Bruce 8 'B'	Ontario Hydro	860	HWR	1987	92	6,962
Darlington 1	Ontario Hydro	881	HWR	1992[3]	—	—
Darlington 2	Ontario Hydro	881	HWR	1990	1	51
Gentilly 2	Hydro Quebec	640	HWR	1983	70	3,951
Pickering 1 'A'[2]	Ontario Hydro	515	HWR	1971	67	3,040
Pickering 2 'A'	Ontario Hydro	515	HWR	1971	72	3,268
Pickering 3 'A'	Ontario Hydro	515	HWR	1972	34	1,548
Pickering 4 'A'	Ontario Hydro	515	HWR	1973	47	2,138
Pickering 5 'B'	Ontario Hydro	516	HWR	1983	64	2,872
Pickering 6 'B'	Ontario Hydro	516	HWR	1984	98	4,441
Pickering 7 'B'	Ontario Hydro	516	HWR	1985	94	4,232
Pickering 8 'B'	Ontario Hydro	516	HWR	1986	98	4,417
Point Lepreau 1	New Brunswick EPC[4]	635	HWR	1983	98	5,475
TOTAL		**13,993**		***(1991 Average:***	**71)**[5]	**81,043**

Units Under Construction or Planned

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	Percent Complete[6]
Darlington 3	Ontario Hydro	881	HWR	1992	97
Darlington 4	Ontario Hydro	881	HWR	1993	80
Point Lepreau 2	New Brunswick EPC	900	HWR	Indefinite	0
TOTAL		**2,662**			

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[1] COD = Commercial Operation Date (actual or expected)

[2] At Bruce and Pickering stations, there are two, four-unit complexes (A&B) at each site.

[3] Operated at full power in pre-commercial testing during part of 1991.

[4] EPC = Electric Power Company5 Source: Nuclear News

[5] Average does not include those units which entered commercial operation or were retired during 1991.

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capacity factor during 1991, improving on its 1990 level of 96 percent. Candu reactors, designed and developed by AECL and Ontario Hydro, operated well throughout the world, with eight of them achieving annual capacity factors in excess of 90 percent.

Ontario Hydro continued its retubing program. Pickering 1, 2, and 3 have been completed, while Unit 4 should be back in service in 1993. Bruce 1 and 2 are scheduled for retubing beginning in 1994 and 1997, respectively. Also, a separate program was initiated in mid-1991 to rehabilitate Bruce Units 1 through 4 over the next eight years at an estimated cost of C$854 million. New Brunswick Power continues to evaluate the economics of constructing a second unit at Point Lepreau. The utility is considering a CANDU-6 design.

In late 1990, Ontario Hydro began investigating a refueling problem at Darlington 2, which revealed damage to some fuel bundles. Consequently, Unit 2 was shut down in January 1991 for a more detailed examination and analysis of the problem. Unit 1, which had achieved full power in the same month, was shutdown in March 1991 to carry out planned commissioning tests and to await the resolution of the problem in Darlington 2. The cause of the problem proved evasive, and only recently have experts from Ontario Hydro, AECL, and General Electric Canada been able to identify the cause. It is believed that with the current configuration of the primary heat transport system in the Darlington reactors, the five-blade impellers in the primary cooling pumps create a resonant frequency that produce vibrations leading to erosion and fatigue damage of the fuel bundles. The engineers believe the problem can be solved, retrofits made, and the unit restarted in the second half of 1992. Meanwhile, Darlington 1 was restarted in early December 1991 and reached full power by year end.

The Ontario provincial government, which was elected in September 1990 and is controlled by the socialist New Democratic Party, has dramatically changed the original 25-year plan for future generation announced by Ontario Hydro in late 1989. Gone are the plans to construct up to ten 881-MWe nuclear units, in favor of increased demand-side management, subsidized switching from electricity to natural gas, and additional reliance on non-utility generation.

The province of Saskatchewan executed a memorandum of understanding with AECL involving an investigation into a range of energy alternatives including coal, oil, and alternative generation sources. However, the studies could result in a decision by Saskatchewan Power Corporation of Regina to construct a CANDU-3 reactor in the province.

Table 41
CANADIAN URANIUM PRODUCTION (1987-1991)

Mine	Ownership	Production (Thousand Pounds Equivalent U_3O_8) 1987	1988	1989	1990	1991	1991 Relative To 1990
ONTARIO							
Elliot Lake	Denison Mines Ltd.	4,703	5,054	4,446	3,581	2,083	-41.8%
Panel	Rio Algom Ltd.	2,145	1,999	1,700	1,200	150	-95.3%
Quirke	Rio Algom Ltd.	2,896	2,891	2,750	2,000		
Stanleigh	Rio Algom Ltd.	1,219	1,217	1,200	1,200	1,280	+ 6.7%
SASKATCHEWAN							
Cluff Lake	Amok Ltd. (80%) Cameco (20%)	2,154	2,235	1,890	2,005	1,800	-10.2%
Key Lake	Cameco (66.7%) Uranerz (33.3%)	13,517	12,033	12,720	12,935	14,100	+ 9.0%
Rabbit Lake/Collins Bay	Cameco (66.7%) Uranerz (33.3%)	5,709	6,965	4,670	0	1,900	—
TOTAL		**32,343**	**32,394**	**29,376**	**22,921**	**21,313**	**-7.0%**

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URANIUM PRODUCTION

Once again, Canada emerged as the leading Western uranium producer during 1991. However, the industry underwent severe dislocations as the result of the renegotiation/termination of long-term uranium sales agreements involving the Elliot Lake producers, Denison Mines Ltd. and Rio Algom Ltd.

In the aggregate, Canadian uranium production declined by seven percent for the year, to 21.3 million pounds U_3O_8 from the 1990 total of 22.9 million pounds U_3O_8 (**Table 41**). Elliot Lake output fell by more than 50 percent, while Saskatchewan producers displaced a portion of that loss by increasing production by almost 20 percent. The restart of the Rabbit Lake Mill made a significant contribution to that improvement.

Elliot Lake, Ontario

Elliot Lake uranium mine production plummeted by 56 percent during 1991 compared to 1990, and the total 1991 output of 3.5 million pounds U_3O_8 is 65-percent lower than the production level attained during 1989.

Rio Algom Ltd. ceased production at its Panel and Quirke mines, as these facilities entered restoration and reclamation. The company's principal focus will now be continued production from the Stanleigh Mine, as a consequence of the renegotiation of the long-term sales agreement with Ontario Hydro. The renegotiated contract shortens the term of the contract significantly, but calls for the utility to take delivery of increased quantities through mid-1996. Ontario Hydro will pay the original contract purchase price for 3.7 million pounds U_3O_8 to be delivered through mid-1993. An additional 5.9 million pounds U_3O_8 are now scheduled for delivery over and above the original contract volume during that period, at a lower price, but still well above current spot price levels.

Denison Mines Ltd. reduced output from its Elliot Lake mine by almost 42 percent, down to 2.1 million pounds U_3O_8 from the 1990 level of almost 3.6 million pounds U_3O_8. Unlike the Ontario Hydro/Rio Algom renegotiation, Ontario Hydro cancelled its contract with Denison, with deliveries scheduled to be completed by May 1992. This termination has lead to an escalating legal process in which Denison claims that Ontario Hydro must pay for anticipated reclamation costs for the Denison mine and mill complex.

Saskatchewan

Increased Key Lake output, coupled with the restart of the Rabbit Lake mill, resulted in a 19-percent increase in 1991 Saskatchewan uranium output. Total production approximated 17.8 million pounds U_3O_8, an increase of more than 2.8 million pounds from the previous year.

In 1991, Cameco Corporation operated the Key Lake mill at greater than its nameplate capacity of 12 million pounds

Figure 49 — Underground Development at the Eagle Point Uranium Deposit. The Eagle Point Mine will feed the Rabbit Lake Mill. *(Photo courtesy of Cameco)*

per year, increasing production by nine percent above 1990 levels, to a record 14.1 million pounds U_3O_8. The company plans to develop the McArthur River deposit in the latter half of the 1990s in order to maintain production levels at Key Lake well into the next century.

The Rabbit Lake mill was restarted in August after a shutdown of two years. Utilizing mill feed from the 18 million-pound stockpile of Collins Bay B-Zone (open pit), the mill produced 1.9 million pounds U_3O_8. During the shutdown period, Cameco completed modifications to the solvent-extraction circuits that will allow for the production of up to 12.0 million pounds U_3O_8 per year as market conditions warrant. Cameco plans to develop the underground Eagle Point mine as the next ore source for the Rabbit Lake mill (**Figure 49**).

Amok Ltd. reported 1991 production at Cluff Lake equalled 1.8 million pounds U_3O_8, a 10-percent decline from 1990.

EXPLORATION AND DEVELOPMENT

Projects

According to Energy, Mines and Resources Canada (EM&R), exploration successes in northern Saskatchewan, as well as the Northwest Territories, will more than compensate for the loss from production and decreased resource estimates by the closing of Elliot Lake. Known uranium resources in Canada recoverable from mineable ore totalled 1.54 billion pounds U_3O_8 as of January 1, 1991 (**Table 43**)

Cigar Lake Mining Corporation reported the successful conclusion of a recent test mining program at the Cigar Lake deposit. Utilizing a remote-controlled boring machine, 50 tonnes of high-grade ore (17 % U_3O_8) were extracted from the main ore body. The material was transported to the surface for storage.

Cameco Corporation increased the reserve estimate for the mcarthur River deposit. The latest estimate now places the reserve at 260 million pounds U_3O_8 at an average grade of 5.0 % U_3O_8. This deposit is planned as a replacement for the Deilmann mine output as mill feed for the Key Lake Mill in the late-1990s. During the year, Cameco acquired a three percent reversionary interest in the mcarthur River deposit for C$6.0 million.

Table 42
URANIUM EXPLORATION ACTIVITY IN CANADA 1980–1990

Year	Total Spent ($C Million)	Total Drilled (km)	Million Dollar Projects
1980	128	503	24
1982	71	247	13
1984	35	197	12
1986	33	162	11
1988	59	202	11
1989	58	158	11
1990	45	66	11

Source: Energy, Mines and Resources Canada

Minatco Ltd., a wholly owned subsidiary of Total Compagnie Minière, continued pre-development activities on the Wolly Project (McClean Lake) in northern Saskatchewan. A verification drilling program has led to a reserve estimate of 60 million pounds U_3O_8 for the project, with development scheduled for 1996-1997. A formal environmental impact statement was filed near the end of 1991.

The Midwest Uranium Project remains poised for governmental approval of its environmental impact statement (EIS). Submitted in late 1990, Denison Mines updated portions of the EIS during 1991, principally in the area of waste management and radiological control. Denison reported that discussions were in progress regarding the possible joint-venture development of the project in conjunction with other uranium projects in the area of Midwest.

Table 43
ESTIMATES OF URANIUM RESOURCES RECOVERABLE FROM MINEABLE ORE
(Million pounds U_3O_8 mineable at a price of up to C$115/lb. U_3O_8)

Principal Resource Categories	Recoverable Resources as of January 1, 1990	Recoverable Resources as of January 1, 1991
Measured	179	127
Indicated	554	577
Inferred	782	839
TOTAL	1,515	1,543

Source: Energy, Mines and Resources Canada

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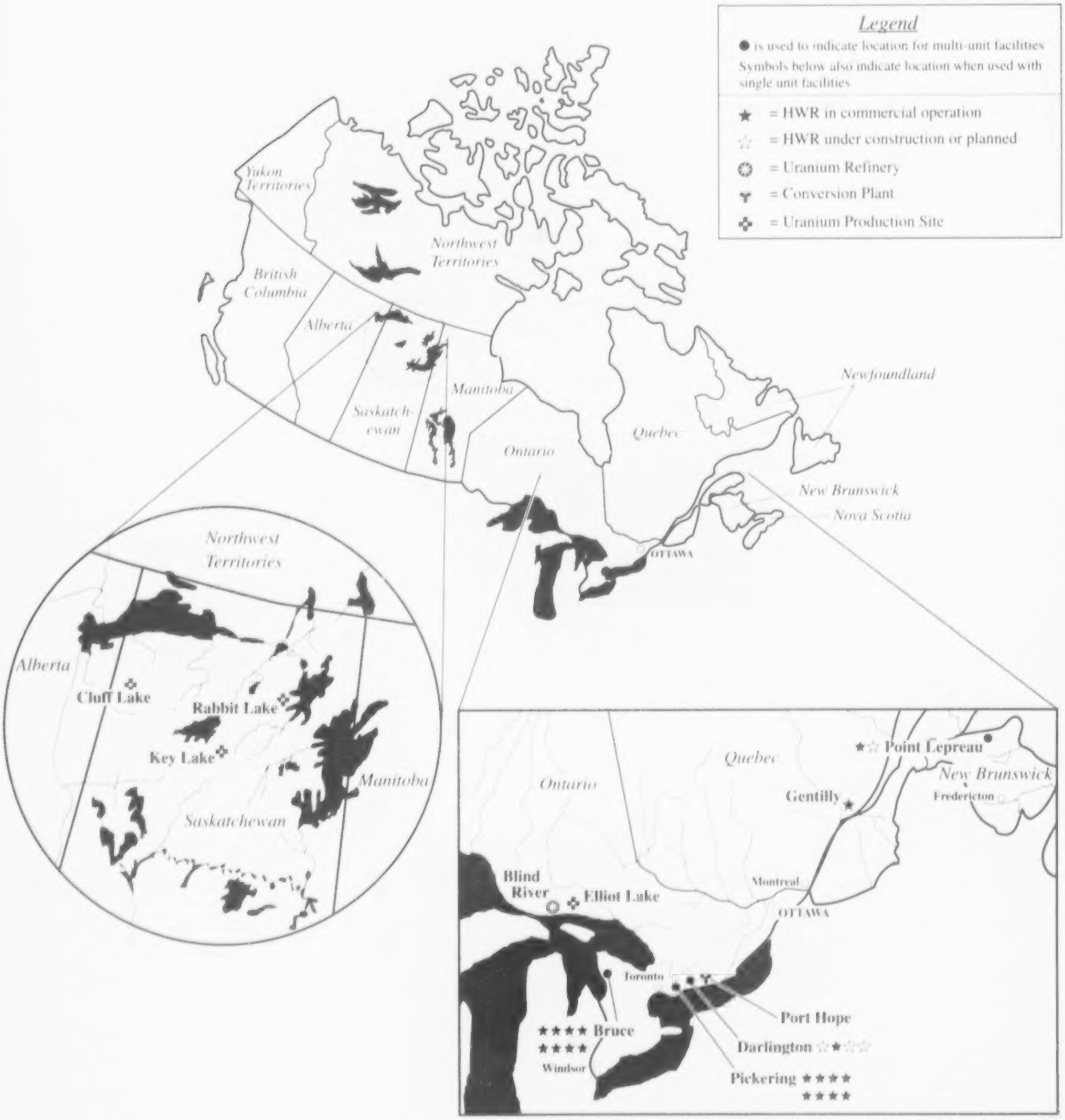
Figure 50
NUCLEAR POWER UNITS AND URANIUM PRODUCTION AREAS IN CANADA



Joint Federal-Provincial Environmental Review Panel

In April 1991, the Federal Environment Minister, Robert de Cotret, and the Saskatchewan Public Safety Minister, Grant Hodgins, announced the formation of a joint federal-provincial review panel for proposed uranium developments (**Table 44**). The panel's charter is to review the environmental health, safety, and socio-economic impacts of proposed developments. More importantly, the panel will assess the cumulative impact of proposed uranium projects.

The panel will deal initially with the environmental impact statements filed for the Dominique-Janine Extension at Cluff Lake (Amok Ltd.), the McClean Lake Project (Minatco) and the Midwest Joint Venture at South McMahon Lake (Denison Mines Ltd.). The panel also will identify issues and establish guidelines for the preparation of environmental impact statements for two projects: the McArthur River Joint Venture (Cameco Corporation) and the Cigar Lake Project (Cigar Lake Mining Corporation).

Table 44
UNDEVELOPED CANADIAN URANIUM DEPOSITS
(Scheduled for production before 2000)

Deposit	Location	Ownership	Reserves (Million Pounds Equivalent U_3O_8)
McArthur River	Saskatchewan	Cameco (44.0%) Uranerz (29.4%) AGIP Resources Ltd. (10.0%) Interuranium Canada Ltd. (9.1%) Cogema Canada Ltd. (6.5%) Imperial Metals Corp. (1.0%)	260
Cigar Lake	Saskatchewan	Cameco (48.750%) Cogema (36.375%) Idemitsu Kosan (12.875%) KEPCO[1] (2.000%)	385
Wolly (McClean Lake)	Saskatchewan	Minatco[2] (100%)	60
Midwest	Saskatchewan	Denison (45.0%) Bow Valley (20.0%) Uranerz (20.0%) OURD[3] (15.0%)	56

[1] KEPCO = Korea Electric Power Corporation. KEPCO purchased a two-percent non-voting interest in Cigar Lake.
[2] Minatco = Minatco Limited, a wholly owned subsidiary of Total Compagnie Miniere (France).
[3] OURD = Overseas Uranium Resources Development Company Ltd. of Japan.

CAMECO CORPORATION PRIVATIZATION

Cameco successfully completed its initial public offering on July 11, 1991. Net proceeds of C$121 million were applied toward a reduction of corporate debt. After subsequent offerings, Cameco was owned, as of January 30, 1992, by the government of Saskatchewan (39 percent), the government of Canada (19 percent) and the public (42 percent).

POLICY REVISION ON FURTHER PROCESSING OF URANIUM

Canada's Minister of Energy, Jake Epp, announced a modification and eventual phase-out of the federal policy that originally required further processing in Canada of all uranium mined in the country. Any new uranium contracts reviewed by the federal government after December 15, 1991, will not be subject to the further processing requirement. Moreover, the further processing requirement will not apply in the event options to extend existing contracts are exercised. While the policy will remain in effect with respect to those deliveries under contracts approved prior to December 15, 1991, that requirement will expire on December 31, 1995.

MEXICO

Mexico has only one nuclear power project—the two-unit Laguna Verde station. Located about 70 kilometers north of Veracruz on the Gulf of Mexico, Laguna Verde 1, a 640-MWe BWR, reached commercial operation in July 1990. It operated very well, setting a new world record of 250 consecutive days of operation from its initial commercial operation date. It shut down for a scheduled refueling in August 1991, having achieved a capacity factor of 88 percent for its first cycle. Its first refueling went smoothly, taking 72 days. The plant resumed operation on November 12, and by year end had generated 4,022 GWh during 1991 and achieved a capacity factor of 72 percent for the year.

The state-owned utility, Comisión Federal de Electricidad (CFE), operates the station. Laguna Verde 2 is still under construction and approximately 72-percent complete (**Figure 51**); it is expected to reach commercial operation in 1994. Organizational changes, economic problems, and design changes have delayed the station's completion. Mexico is making the transition to an industrialized country, and consequently, its energy demand is expected to continue to grow rapidly at seven percent per year. The potential for a North American Free Trade Agreement between Canada, Mexico, and the USA, may further speed this transition and make the need for power even greater. Thus, the completion of Laguna Verde is essential, as the station is expected to provide over five percent of the country's total electricity generation.

Mexico's main uranium deposits are located in the states of Nuevo León and Chihuahua and total approximately 20 million pounds equivalent U_3O_8 of reasonably assured resources, although no deposits have yet been developed. Mexico recently enacted laws that will permit foreign ownership in mineral joint ventures, but uranium was specifically excluded from this new law because it is considered a strategic mineral.

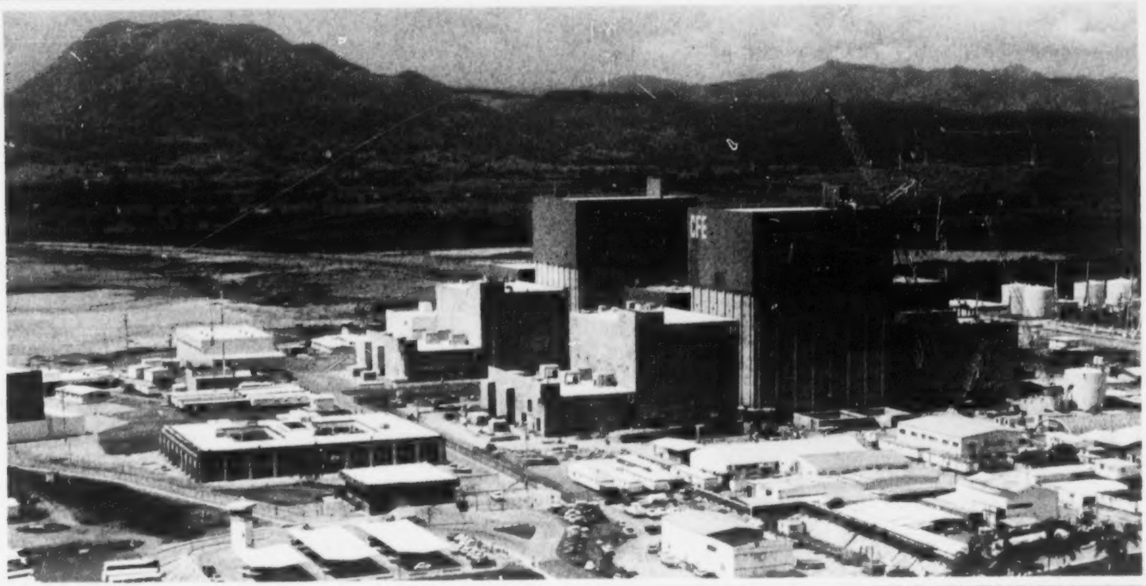


Figure 51 — Laguna Verde Nuclear Power Station. *(Photo courtesy of CFE)*

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UNITED STATES

OVERVIEW

The US nuclear power industry moved closer to recovery in 1991, but it is clear change will be slow. Industry officials and participants echoed the same themes from the last several years, including new reactor designs, the streamlining of plant licensing, frustration over the high-level waste program, low uranium prices, and further cutbacks and consolidation in the uranium industry. The task of increasing public acceptance of nuclear power in the USA continues to be a long and difficult project for the industry, bolstered only by slow, grudging acceptance when compared to the alternatives. Controversy and political intervention surrounding free trade in the uranium market arose again in 1991, as sanctions against South Africa were lifted on the one hand, and an anti-dumping petition was filed against Soviet uranium on the other. The year 1991 also signalled renewed activity in the long-term enrichment market, the first real activity since the US Department of Energy (DOE) issued the Utility Services Contract in 1984. New competitors sought to break into the long-term market for enrichment, as Eurodif and Urenco did in the early 1980s.

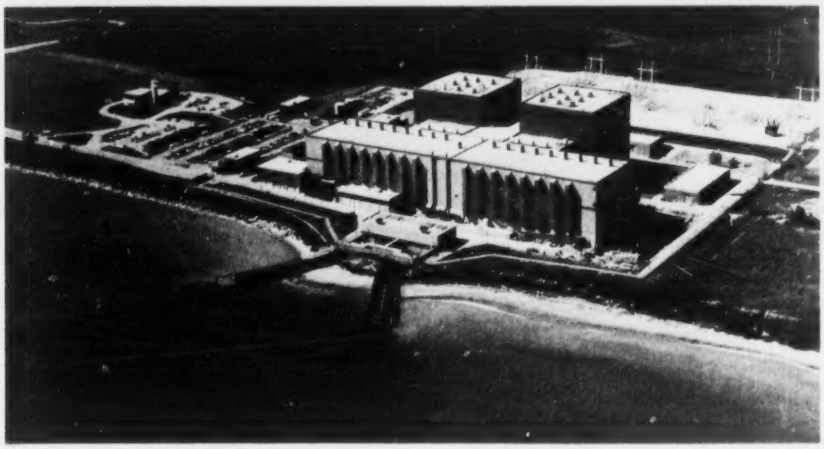

Figure 52 — Point Beach Nuclear Power Station. *(Photo courtesy of WEPCO)*

NUCLEAR POWER DEVELOPMENTS

No new units entered commercial operation in 1991, the first year in which this has occurred since the beginnings of the US commercial nuclear power industry in the late 1960s. Thus, the current construction phase for the US nuclear power industry is nearing an end. Only two units remain under construction: Texas Utilities Electric Company's Comanche Peak 2, and Tennessee Valley Authority's (TVA) Watts Bar 1. Both units are expected to enter service in 1992. At that time, 113 operating nuclear units will have a total capacity exceeding 100 thousand MWe, and will maintain about 20 percent of US electricity generation (**Table 47**). Another seven units remain partially completed and are categorized as indefinitely deferred. Included in this group are three TVA units (Watts Bar 2 and Bellefonte 1 and 2) and two Washington Public Power Supply Service units (WNP 1 and 3). None have formal startup dates. Another TVA unit, Browns Ferry 2, was restarted in August 1991 after a six-year hiatus due to safety concerns. Since 1985, TVA has spent more than $1.2 billion on improvements at the three-unit site. The other two units remain shut down, but restart of Unit 3 is expected in 1993, and restart of Unit 1, in 1995.

Perry 2, another unit on this indefinitely deferred list, is owned by the CAPCO consortium utilities in Ohio and Pennsylvania. The owners of the plant have asked the NRC to extend the construction permit for the unit by another ten years. The original permit has been in place since 1977, but financial difficulties and lack of demand for power caused the unit to be suspended in 1985. The deferred unit, which costs about $1 million per year to maintain, may cost as much as another $2 billion to complete. The permit extension would allow the joint owners another ten years to determine a strategy for completing, selling, or formally cancelling the unit.

Also included in the deferred group is Long Island Lighting Company's (LILCO) controversial Shoreham unit, the only fully completed unit in the USA ever to have been shutdown by political intervention prior to commercial operation. In October 1991, the New York Court of Appeals upheld the agreement between the state of New York and LILCO that allowed the utility to transfer ownership of the plant to the Long Island Power Authority (LIPA) for the sum of one dollar. The agreement also allows LILCO to recover some of its $5 billion investment from ratepayers over an eleven-year period. LILCO is now awaiting NRC approval on its decommissioning plan for Shoreham, which will involve LILCO, LIPA, and the New York Power Authority.

On a more optimistic note, two US reactors surpassed the 100 billion kWh lifetime generation mark on consecutive days in the summer of 1991. Duke Power Company's Oconee 1 achieved the milestone on July 28, and American Electric Power Company's Cook 1 reached that mark the following day. The two units are the first to achieve that performance standard in the USA; previously, only units in Germany and Belgium had surpassed that mark. Oconee is a 846-MWe PWR that began commercial operation in 1973, and Cook is a 1,202-MWe PWR that entered service in 1975.

In other news, the US nuclear industry recently announced that it had secured more than 90 percent of utilities' commitments toward its $50 million share of funding for the development of prototype engineering in the advanced light-water reactor program. Nuclear equipment vendors will contribute another $50 million after the first year of the program. These contributions by the commercial nuclear industry will match DOE's planned five-year infusion of $100 million into the engineering portion of advanced LWR development.

Figure 53 — Palo Verde Nuclear Power Station. *(Photo courtesy of Arizona Public Service Co.)*

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LICENSING

Yankee Atomic Electric Company, which owns and operates the oldest commercial nuclear plant in the USA at Rowe, Massachusetts, became embroiled in a debate over license extension and pressure vessel embrittlement during 1991. Yankee had petitioned the NRC for an operating license extension from 2000 to 2020, which would have been the first license extension in the USA. Concerns about the level of vessel embrittlement caused Yankee to postpone the submission in mid-July after the NRC reversed an earlier ruling approving the extension. The new NRC Chairman, Ivan Selin, objected to his predecessor's approval of the ruling prior to its exact finalization. The delay, in addition to vocal opposition against the plant's operation, led Yankee to reconsider the request.

Following an NRC staff recommendation to shut down the plant, Yankee officials decided to voluntarily cease operations in advance of the planned April 1992 outage. The staff recommended that the unit be shut down pending additional analysis of how the unit would respond in certain accident scenarios, particularly the pressurized thermal shock associated with the sudden rush of cold water introduced in an emergency cooling situation. Yankee used this time to gather data on the embrittlement and prepare its case to the NRC. After several months of evaluation, Yankee estimated that it could spend at least $23 million more on analysis. Given this situation, and the plant's high operating costs, on February 26, 1992, Yankee's Board of Directors voted to close the plant permanently.

In October, the NRC unanimously approved new regulations for 20-year license extensions of US nuclear power plants. NRC Chairman Ivan Selin stated that the license extension process is "tough", as it requires the operating utility to submit the results of extensive technical analyses in support of its application to operate a reactor 20 years beyond its original 40-year license.

The new regulations do not require utilities to compile and submit documentation for the current licensing basis (CLB) for the plant. The CLB includes all NRC regulations, requirements, rules and all utility commitments to the NRC over the operating life of the reactor. While the CLB would provide the NRC with useful additional information for considering the safety of the plant's operation in the extension period, it would require the utility to submit several thousand more documents, greatly increasing the cost of the application and the time necessary for review. Inclusion of the CLB in the application also might open a plant's current operation to intervenor actions. The license renewal review process allows for public comment, on issues relating to operation of a plant during the 20-year extension period, not on issues concerning its current 40-year license.

Licensing reform issues also were considered in 1991, both as part of comprehensive energy legislation and in separate bills. The numerous efforts to reform the licensing process for standardized, advanced nuclear plants had three main areas in common. The first area was writing the laws that would combine the construction permit and operating license proceedings (one-step licensing). The second was outlining the formal procedures for hearings, and third, specifically remove the post-construction hearings currently required before plant operation. These efforts were included as part of Sen. J. Bennett Johnston's (D-LA) energy bill, which may pass during 1992.

URANIUM CONTRACTING

Thirteen US utilities accepted 23 proposals and entered negotiations for long-term supply of uranium during 1991. Four of those contracts involved natural UF_6, one involved enriched uranium product (EUP), and the balance, U_3O_8. Estimates using nominal delivery quantities result in approximately 23 million pounds equivalent U_3O_8 scheduled for delivery during the period 1992-2001. This total volume falls between the 1990 total of 31 million pounds U_3O_8 equivalent (in 24 contracts) and the 1989 total of 21 million pounds U_3O_8 equivalent (in 17 contracts).

US companies were the sellers in only five of the contracts; the other sellers were primarily Canadian producers. In six cases, the sellers were intermediaries, and seven of the contracts involved non-North American sellers.

In somewhat of a departure from the long-standing trend in the USA, fully half of the contracts signed or in negotiation in 1991 contained fixed or base-price-escalated pricing mechanisms. This statistic suggests that low spot-market prices have contributed to the decline of base prices under long-term contracts, and to the fact that

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US utilities now seem to have more of an inclination to evaluate base-priced offers. Certain utilities have shown an interest in at least partially hedging against a rise in the spot market price, and several of those participated in procurement exercises during 1991.

Another contributing factor may be that some producers are no longer willing to offer discount-from-market contracts, a practice that has yielded mixed results, in that these contracts fail to take into consideration a producer's production costs. Once producers began offering this mechanism in the early 1980s, US utilities overwhelmingly demanded the market-related contract as the preferred form of pricing because of the perceived low risk, not only from a price standpoint but also as a way of deflecting Public Utility Commission criticism. The argument held that, despite spot market price movement, no utility could be criticized for always purchasing at a discount from the then-current spot market. Ceiling prices helped protect the utility in the event of an unexpectedly sharp rise in spot prices. Floor prices designed to protect the producer soon either disappeared under intense competition in the strongly buyer's market, or became "soft" or "walkaway" floor prices. Those soft floors technically allowed the producer not to deliver if the spot market price fell below a certain level. However, in an effort to retain market share, two scenarios for producers quickly developed: the lowest-cost producers continued to deliver, and the higher-cost producers bought from the marketplace to fulfill their contracts. Both practices continue today.

In other contracting news, DOE without formally announcing its Incentive Price 3 (IP-3) proposal, did begin an aggressive marketing effort in 1991, believed to have been brought on by increased competition for the post-1995 marketing. On a case-by-case basis, DOE has negotiated prices reported to be around $90 escalated for the last 30 percent of a customer's requirements. In other situations, DOE reportedly exhibited unusual flexibility regarding feed delivery and notice provisions. DOE's position is that it has the authority to make these offers based on the revised criteria for enrichment published in 1986, which allow DOE to negotiate on an individual basis with customers defined as "similarly situated". As a result, competition for the post-1995 SWU market in the USA increased markedly during 1991 and should continue into 1992.

FUEL CYCLE DEVELOPMENTS

On November 8, 1991, some companies with US uranium production interests, and the Oil, Chemical and Atomic Energy Workers Union filed a petition with the US Department of Commerce and the US International Trade Commission (ITC) charging that uranium was being dumped in the United States by the Soviet Union. The petition claimed that Soviet trade practices were causing injury and threatening further injury to the US uranium industry.

On December 3, the staff of the ITC held a public conference as part of its investigation regarding the petition. The purpose of the ITC investigation is to determine if injury to the domestic uranium industry has been caused by the Soviet imports. After the testimony and briefs from each party elaborating their respective positions, the ITC staff assembled and analyzed the issues for the commissioners assigned to the case, who were responsible for a preliminary determination whether to dismiss the petition or continue the investigation.

On December 18, the ITC commissioners made a preliminary decision that the petition merited further investigation. The procedure was continued by the International Trade Administration of the Department of Commerce, which has 160 days to ascertain if, in fact, the Soviet uranium marketed in the USA was sold at less than fair market value.

Prior to the filing of the petition, Sen. Malcolm Wallop (R-WY) had amended the enrichment bill (S 210) to require the ITC to investigate imports of uranium and enriched uranium from non-market economies to the USA and determine whether prices of this material are below costs of production. The amendment also authorizes DOE to purchase, rather than produce, enriched uranium as long as the price is below its cost of production. The ITC report, in response to the Wallop Amendment, was scheduled to be sent to the President by July 1992; however the ITC has been given a six month extension due to the filing of the dumping petition.

In October, NRC ordered Sequoyah Fuels Corporation not to restart its UF_6 conversion operations in Gore, Oklahoma, pending further NRC review of the plant's environmental and health and safety programs. The plant had been shut down for a routine two-week maintenance period when the order was issued. Later, the NRC demanded that Sequoyah take action in numerous areas related to the plant's environmental and safety management. Sequoyah is working toward compliance with these requests and is expected to be allowed to restart in 1992.

Also in 1991, in recognition of South Africa's steps toward democratization and the dismantling of apartheid, the USA removed sanctions on uranium of South African origin, ending a five-year embargo. Because of reduced levels of production in South Africa, the country's lack of participation on the spot market, and the US utilities' reluctance to change their purchasing policies to allow South African material, the removal of sanctions had no real effect on the market in 1991.

LEGISLATIVE DEVELOPMENTS

Because of the war in the Persian Gulf, 1991 began with a legislative push to enact energy policy legislation. The nuclear industry worked to build momentum by releasing the Nuclear Power Oversight Committee's report entitled "A Strategic Plan for a New Nuclear Plant Order" and by supporting the Bush Administration's National Energy Strategy. Some DOE energy proposals require Congressional funding, and in a period of declining budgets, several nuclear programs experienced a reduction in funding, such as the Atomic Vapor Laser Isotope Separation (AVLIS) program. After the war ended, Congressional interest waned and the momentum to enact a comprehensive energy policy faded.

Recognizing that the window of opportunity to enact energy legislation was small, the Senate moved quickly in April, holding more than 15 hearings on various energy options, including nuclear licensing reform and standardized plant designs. At the end of the month, markup was held on a 16-title energy bill, which included one title on restructuring the uranium enrichment program into a government corporation. This title is virtually identical to last year's enrichment bill S210 sponsored by Sen. Wendall Ford (D-KY). The bill was approved by the Senate on June 12, but as a part of the omnibus energy package, its fate had not been determined as of the end of 1991. Sen. Ford's strategy has been to continue on two tracks: if the bill has not been passed by the House of Representatives before the end of the 102nd Congress, S210 can be amended to any "must-pass" legislation in 1992, thereby forcing the House to hold a conference committee on the issue. The alternative is for the bill to remain part of the omnibus energy bill and let its fate in the House rest with the other parts of the energy package.

ENRICHMENT

The three House committees with jurisdiction over enrichment legislation demonstrated more interest in the issue this year. Rep. Philip Sharp (D-IN) Chairman of the Energy & Power subcommittee, held a hearing in April on a number of options for restructuring DOE's enrichment program. In October, Rep. Sharp's subcommittee marked up a new version of a restructuring bill that retained many of the concepts considered previously by both the Administration and the Senate. The outcome was a bill creating a government corporation that can eventually be privatized. No initial "debt" is created, other than the obligation to repay a loan of $364 million from the Treasury, which would be used as a working capital fund. The bill allows AVLIS to be deployed only if the corporation has become privately owned. The bill created some concern in the utility industry because of a provision to collect money for decommissioning and decontamination (D&D) of gaseous diffusion plants (GDP) via a millage fee on US utilities. The committee based its estimate of cost for D&D of the GDPs on the unofficial total of $20 billion published in the report issued by Ebasco, a DOE contractor. The figure is very controversial, and DOE has refused to publicly state its policy on the question.

In order to raise the D&D money, the bill calls for the corporation to contribute $500 million per year (indexed to inflation) to a special fund. A three-tiered formula is used to raise the money: first, lease payments for the GDPs; second, royalty payments for AVLIS; and third, the funds designated as repayment of the $364 million "debt". If $500 million is not raised from those sources, the committee's proposal then calls for a millage fee to be assessed on all nuclear power plants in the USA. However, at the markup, Rep. Carlos Moorhead (R-CA) offered a counterproposal which would levy a retroactive fee on DOE's enrichment customers "subject to a DOE rule-making." This alternative was accepted and essentially bought more negotiating time for the interested parties. However, many members of the committee remain convinced that a millage fee is the best guarantee of a revenue stream for the fund. Unlike the Senate bill, which accepts a 50/50 split, no mention has been made of the military's share of the fund. The threat of a millage fee will remain until another proposal for raising funds is offered. It is unlikely the concerns of the utilities will be resolved until full committee markup in 1992. Rep. Sharp's enrichment proposal is included in the omnibus energy

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package being considered by the Energy & Commerce Committee and likely will reach the House floor in the summer of 1992.

For the first time, a subcommittee of the Interior Committee also took an interest in the enrichment issue. The Energy & Environment Subcommittee chaired by Rep. Pete Kostmayer (D-PA) held a hearing on the subject, and Rep. Kostmayer indicated he intends to introduce legislation early in 1992.

AVLIS also received considerable Congressional attention during the year. DOE reduced its request for funding for AVLIS deployment work, and although it appeared the program had support in Congress for full funding, other budget priorities won out and the program was cut by $50 million. Not only were future plans such as the request for proposals (RFP) for the commercial deployment contractor delayed, but some of the demonstration work also will slow down, putting the program another six months behind schedule. DOE did announce that it had narrowed the site selection process down to the three present GDP sites, and that work on data collection for the environmental impact statement is continuing. At year end, DOE reportedly was cutting more funds from the program in its FY1993 budget request, making the commercialization of AVLIS uncertain.

Little news of the development of AVLIS emerged during 1991. An official from Lawrence Livermore National Laboratory charged with the technical development of AVLIS stated in mid-1991 that a small AVLIS plant of about 4 million SWU capacity could be ready for commercial deployment as early as 1997. LLNL still projects a factory cost of about $25 to $50 per SWU. The US nuclear industry appears to view these estimates with some skepticism, given the slow development of the project, and the lack of a concrete plan of action to deploy the technology.

The technology continues to generate interest, however, and was the focus of several industry reports during the year. The Edison Electric Institute published a study on the status of AVLIS, expressing concern about production cost estimates and urging continued progress toward deployment. In October, the National Academy of Sciences issued its report on alternative uses for AVLIS. The primary recommendation of the Academy's report was that DOE and the national laboratories should "allow industry to play a greater and an earlier role in the definition and development of the technology, if the USA is to derive significant commercial benefit from research done at the labs." Eight companies and two federal organizations have already expressed interest in the alternative applications.

Louisiana Energy Services (LES), hoping to become the first privately owned uranium enrichment venture in the USA, filed an application with the NRC on January 31, 1991, for a construction and operating license. The centrifuge plant, employing Urenco technology, is planned for construction in Claiborne Parish, Louisiana. LES has begun marketing the output of the planned facility to US utilities. One utility, Northern States Power, has entered into a contract with LES for some portion of its post-1995 enrichment requirements. (A subsidiary of Northern States Power (NRG), along with Entergy Services and Duke Power Company, are equity participants in the venture). The NRC may take up to two years to consider the application, and a formal public hearing must be held before the NRC completes its review. Construction of the plant is scheduled to begin in early 1993, assuming timely approval of the license.

Techsnabexport and CONCORD, through its affiliate NUEXCO Exchange AG, formed a joint venture to market certain products of the ex-Soviet Ministry of Atomic Energy and Industry, including uranium and enrichment services. The joint venture, which now includes as a partner the uranium enrichment plant in Ekaterinburg (formerly Sverdlovsk), was named Global Nuclear Services and Supply Ltd. (GNSS). GNSS opened offices in Zurich, Moscow, and Washington, DC, in October 1991 and began marketing Russian enrichment services and other products.

How weapons-grade material might impact the civilian uranium and enrichment markets also received the attention of Congress this past year. After review of its cleanup plans at Fernald, DOE determined that some portion of the "scraps" left from weapons production, with further processing, might be of interest to the private sector. DOE issued a request for expression of interest from the commercial sector in March 1992, but the RFP seems caught in the bureaucracy. However, it is expected that at some point the opportunity will be provided to bid on some or all of the "useful material". After the USA and the former Soviet Union signed the historic Strategic Arms Reduction Treaty, Congress also began to discuss what uses there might be for material coming from dismantled warheads.

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SPENT FUEL

There was progress during the year on characterizing the spent fuel repository at Yucca Mountain (**Figure 54**). In February, DOE awarded the $1 billion systems engineering, development, and management contract to TRW Environmental Safety Systems. The courts also helped industry efforts to get the program moving, by issuing a federal court order in July ordering Nevada to begin processing environmental permits. Congress also attempted to encourage the state of Nevada into cooperating with DOE. In July, the Senate Energy Committee reported S 1138, a bill that would authorize the Environmental Protection Agency to issue permits the state has withheld, thus allowing DOE to proceed with characterization. The day after the vote, the Nevada State Department of Environmental Protection issued two of the 18 environmental permits that had been pending for over a year. At year end, DOE announced it would not start work on the underground facility as planned, deciding instead to continue surface tests. The state of Nevada continued to oppose DOE's efforts to move the program forward, by continuing to delay issuing necessary environmental permits.

Senate bill 1138 also would repeal sections of the Nuclear Waste Policy Act related to the Monitored Retrievable Storage (MRS) facility. The new bill would allow DOE to begin the selection process for an MRS host state, uncoupling the permanent repository siting from the MRS. This legislation remained separate from the omnibus energy bill in the Senate, although the House is considering the issue as part of its omnibus energy package. Nuclear waste negotiator David Leroy did have success in 1991 in his efforts to locate a volunteer state, since by year end several groups had applied for the federal funds necessary to begin consideration of participation in the MRS siting process.

Figure 54 — Yucca Mountain Site of Proposed DOE Spent Fuel Repository. *(Photo courtesy of DOE)*

URANIUM PRODUCTION

US uranium production continued to decline during 1991. Total production approximated 7.9 million pounds U_3O_8, a decrease of more than 11 percent from the 1990 production level of 8.9 million pounds U_3O_8 (**Table 46**).

Uranium production from conventional sources declined by almost 50 percent, from 4.7 million pounds U_3O_8 to 2.5 million pounds U_3O_8, principally due to the stand-by status of the White Mesa Mill owned by Umetco Minerals/Energy Fuels. White Mesa produced more than 2.3 million pounds U_3O_8 in 1990, but recorded no production in 1991. Production at Pathfinder Mines' Shirley Basin mill increased to an estimated 800 thousand pounds U_3O_8 from the previous year's level of 300 thousand pounds U_3O_8, while the Rio Grande Resources/Total Mining operations at Panna Maria remained relatively stable at 1.5 million pounds U_3O_8. Both of these conventional mills are scheduled for shutdown and decommissioning during 1992.

Uranium production from solution mining (in-situ leaching) totalled 2.2 million pounds U_3O_8 for the year, more than a 50 percent increase compared to the 1990 level of 1.4 million pounds. The Highland uranium project, owned by Power Resources Inc./Interuran, maintained its annual rate at slightly greater than 1.0 million pounds U_3O_8. Uranium Resources, Inc.'s Rosita project (**Figure 55**) tripled its 1990 output by increasing production to 750 thousand pounds U_3O_8.

Significantly, the Crow Butte project in Nebraska, owned by a consortium comprised of Ferret Exploration Company, Inc., First Holding Company/Geomex Minerals, Inc., Uranerz Exploration and Mining Company, and Korea Electric Power Corporation commenced commercial operation during spring 1991, producing an estimated 230 thousand pounds U_3O_8 during the last three quarters of the year. Total Minerals, operator of the Malapai Resources/Total Minerals joint-venture uranium properties restarted its operations in August 1991 at both the El Mesquite (Texas) and Christensen Ranch (Wyoming) projects.

Uranium concentrates produced from phosphoric acid by-product operations proved to be the most significant contributor to US output in 1991. The International Minerals & Chemical (IMC) New Wales and Plant City facilities produced more than 2.0 million pounds U_3O_8. The restart of the Donaldsonville (Sunshine Bridge) facility owned by Freeport Uranium Recovery coupled with production from the Uncle Sam unit resulted in an aggregate output of just under 1.1 million pounds U_3O_8 for that company.

Figure 55 — Rosita ISL Uranium Project. Central recovery plant at URI's Rosita facility in southern Texas. *(Photo courtesy of URI)*

Table 45
US URANIUM PRODUCTION FACILITIES

Production Center	Location	Principal Owner	Type	Annual Capacity (thousand pounds equivalent U_3O_8)
OPERATING[1]				
Crow Butte	Nebraska	Ferret/Uranerz/KEPCO	Solution	500
Rosita	Texas	URI	Solution	800
El Mesquite	Texas	Malapai	Solution	300
Irigaray/Christensen Ranch	Wyoming	Malapai	Solution	500
Highland	Wyoming	Power Resources	Solution	1,000
New Wales	Florida	IMC	By-product (P_2O_5)	1,200
Plant City	Florida	IMC	By-product (P_2O_5)	800
Uncle Sam	Louisiana	Freeport	By-product (P_2O_5)	750
Donaldsonville	Louisiana	Freeport	By-product (P_2O_5)	400
Ambrosia Lake	New Mexico	Rio Algom	By-product (minewater)	200
Grants	New Mexico	Homestake	By-product (minewater)	200
Panna Maria/Rhode Ranch	Texas	General Atomics/Total	Conventional	1,500
Shirley Basin	Wyoming	Pathfinder	Conventional	500
STANDBY[1]				
Hobson	Texas	Everest	Solution	150
Kingsville Dome	Texas	URI	Solution	1,000
West Cole	Texas	Total	Solution	200
Bingham	Utah	Energy Fuels	By-product (Cu)	150
Calgary	Alberta, Canada	Earth Sciences	By-product (P_2O_5)	120
Grants	New Mexico	Homestake	Conventional	300
White Mesa	Arizona/Utah	Energy Fuels	Conventional	3,200+
White Mesa	Colorado/Utah	Umetco	Conventional	500+
Canon City	Colorado	Cotter	Conventional	500
Gas Hills	Wyoming	Pathfinder	Conventional	500
Ambrosia Lake	New Mexico	Rio Algom	Conventional	2,500
Sherwood	Washington	Western Nuclear	Conventional	1,000
Sweetwater	Wyoming	Kennecott/USEC	Conventional	1,000

[1] Status as of 12-31-91

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Table 46

US URANIUM PRODUCTION BY TYPE

(Million Pounds Equivalent U_3O_8)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Conventional	20.6	14.8	9.5	5.4	9.0	8.2	7.4	8.2	4.7	2.5
By-Product	3.2	3.1	3.1	3.6	3.2	3.4	3.5	3.2	2.8	3.2
Solution Mining	3.0	2.8	2.1	2.1	0.9	0.7	2.5	2.4	1.4	2.2
TOTAL	**26.8**	**20.7**	**14.7**	**11.1**	**13.1**	**12.3**	**13.4**	**13.8**	**8.9**	**7.9**

INDUSTRY CONSOLIDATIONS

During the year, Power Resources, Inc. (PRI) acquired the Gas Hills, Wyoming, solution mining properties held by the Tennessee Valley Authority (TVA) and subsequently entered into a mining joint-venture on those reserves with UG Mining, Inc., a US subsidiary of Urangesellschaft mbH of Germany. In addition, Rio Grande Resources, a subsidiary of General Atomics, purchased TVA's Powder River Basin properties, also located in Wyoming.

In one of the most publicized acquisitions of the year, General Atomics acquired all the US and Canadian uranium assets of Chevron Resources. These assets include the Panna Maria uranium mill, a 55-percent share of the Rhode Ranch uranium mine in south Texas, the Mt. Taylor uranium mine in New Mexico (the largest known uranium deposit in the United States), and exploration properties in Saskatchewan, Canada.

In January 1991, John R. Adams, Chairman of Energy Fuels, and Oren L. Benton, owner of NUEXCO, announced a joint venture involving all the uranium assets of Energy Fuels. Energy Fuels holds over 20 million pounds of uranium reserves in northern Arizona.

In February, Uranerz announced the sale of all of its Wyoming uranium properties (including North Butte) to Pathfinder Mines, while during the previous month, Pathfinder Mines sold its Big Eagle Mine to US Energy Corporation/Crested Corporation. In July, Unocal Corporation announced that its Sweetwater mill and reserves would be acquired by the Green Mountain Mining Venture, a joint venture between Kennecott Corporation, US Energy Corporation, and its subsidiary Crested Corporation.

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LICENSED NUCLEAR POWER STATIONS IN THE USA

FUEL BUYER	STATION	
1 - Yankee Atomic Group[1]	Yankee Maine	■
2 - Yankee Atomic Group[1]	Seabrook	■
3 - Yankee Atomic Group[1]	Yankee Vermont	▲
4 - Yankee Atomic Group[1]	Yankee Rowe	■
5 - Boston Edison Co.	Pilgrim	▲
6 - Northeast Utilities	Haddam Neck	■
7 - Northeast Utilities	Millstone	▲■■
8 - Long Island Lighting Co.	Shoreham	△
9 - Consolidated Edison Co. New York	Indian Point 2	■
New York Power Authority	Indian Point 3	■
10 - New York Power Authority	Fitzpatrick	▲
11 - Niagara Mohawk Power Corp.	Nine Mile Point	▲▲
12 - Rochester Gas and Electric Corp.	Ginna	■
13 - Pennsylvania Power and Light Co.	Susquehanna	▲▲
14 - Philadelphia Electric Co.	Limerick	▲▲
15 - Philadelphia Electric Co.	Peach Bottom	▲▲
16 - GPU Nuclear Corp.	Three Mile Island	■
17 - GPU Nuclear Corp.	Oyster Creek	▲
18 - Public Service Electric & Gas	Salem	■■
19 - Public Service Electric & Gas	Hope Creek	▲
20 - Baltimore Gas & Electric Co.	Calvert Cliffs	■■
21 - Virginia Electric Power Co.	North Anna	■■
22 - Virginia Electric Power Co.	Surry	■■
23 - Carolina Power & Light Co.	Harris	■
24 - Carolina Power & Light Co.	Brunswick	▲▲
25 - Carolina Power & Light Co.	Robinson	■
26 - Duke Power Co.	McGuire	■■
27 - Duke Power Co.	Catawba	■■
28 - Duke Power Co.	Oconee	■■■
29 - South Carolina Electric & Gas	Summer	■
30 - Tennessee Valley Authority	Sequoyah	■■
31 - Tennessee Valley Authority	Watts Bar	□□
32 - Tennessee Valley Authority	Bellefonte	□□
33 - Tennessee Valley Authority	Browns Ferry	▲▲▲
34 - Southern Company Services	Vogtle	■■
35 - Southern Company Services	Hatch	▲▲
36 - Southern Company Services	Farley	■■
37 - Florida Power Corp.	Crystal River	■
38 - Florida Power & Light Co.	St. Lucie	■■
39 - Florida Power & Light Co.	Turkey Point	■■
40 - Gulf States Utilities Co.	River Bend	▲
41 - Entergy Operations	Waterford	■
42 - Entergy Operations	Grand Gulf	▲
43 - Entergy Operations	Arkansas	■■
44 - Union Electric Co.	Callaway	■
45 - Illinois Power Co.	Clinton	▲
46 - Commonwealth Edison Co.	Quad Cities	▲▲
47 - Commonwealth Edison Co.	Byron	■■
48 - Commonwealth Edison Co.	La Salle	▲▲
49 - Commonwealth Edison Co.	Dresden	▲▲
50 - Commonwealth Edison Co.	Zion	■■
51 - Commonwealth Edison Co.	Braidwood	■■
52 - CAPCO[2]	Davis-Besse	■
53 - CAPCO[2]	Beaver Valley	■■
54 - CAPCO[2]	Perry	▲△
55 - Detroit Edison Co.	Fermi	▲
56 - American Electric Power Co.	Cook	■■
57 - Consumers Power Co.	Palisades	■
58 - Consumers Power Co.	Big Rock Point	▲
59 - Wisconsin Public Service Corp.	Kewaunee	■
60 - Wisconsin Electric Power Co.	Point Beach	■■
61 - Northern States Power Co.	Monticello	▲
62 - Northern States Power Co.	Prairie Island	■■
63 - Iowa Electric Light & Power Co.	Arnold	▲
64 - Omaha Public Power District	Fort Calhoun	■
65 - Nebraska Public Power District	Cooper	▲
66 - Kansas Gas & Electric Co.	Wolf Creek	■
67 - Texas Utilities Electric Co.	Comanche Peak	■□
68 - Houston Lighting & Power Co.	South Texas	■■
69 - Arizona Public Service Co.	Palo Verde	■■■
70 - Southern California Edison Co.	San Onofre	■■■
71 - Pacific Gas & Electric Co.	Diablo Canyon	■■
72 - Portland General Electric Co.	Trojan	■
73 - WPPSS[3]	WNP 1 & 2	□▲
74 - WPPSS[3]	WNP 3	□

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[1] Yankee Atomic Group consists of Maine Yankee Atomic Power Company, Vermont Yankee Nuclear Power Corporation, Public Service Company of New Hampshire, and Yankee Atomic Electric Company

[2] CAPCO = Central Area Power Coordinating Group

[3] WPPSS = Washington Public Power Supply System

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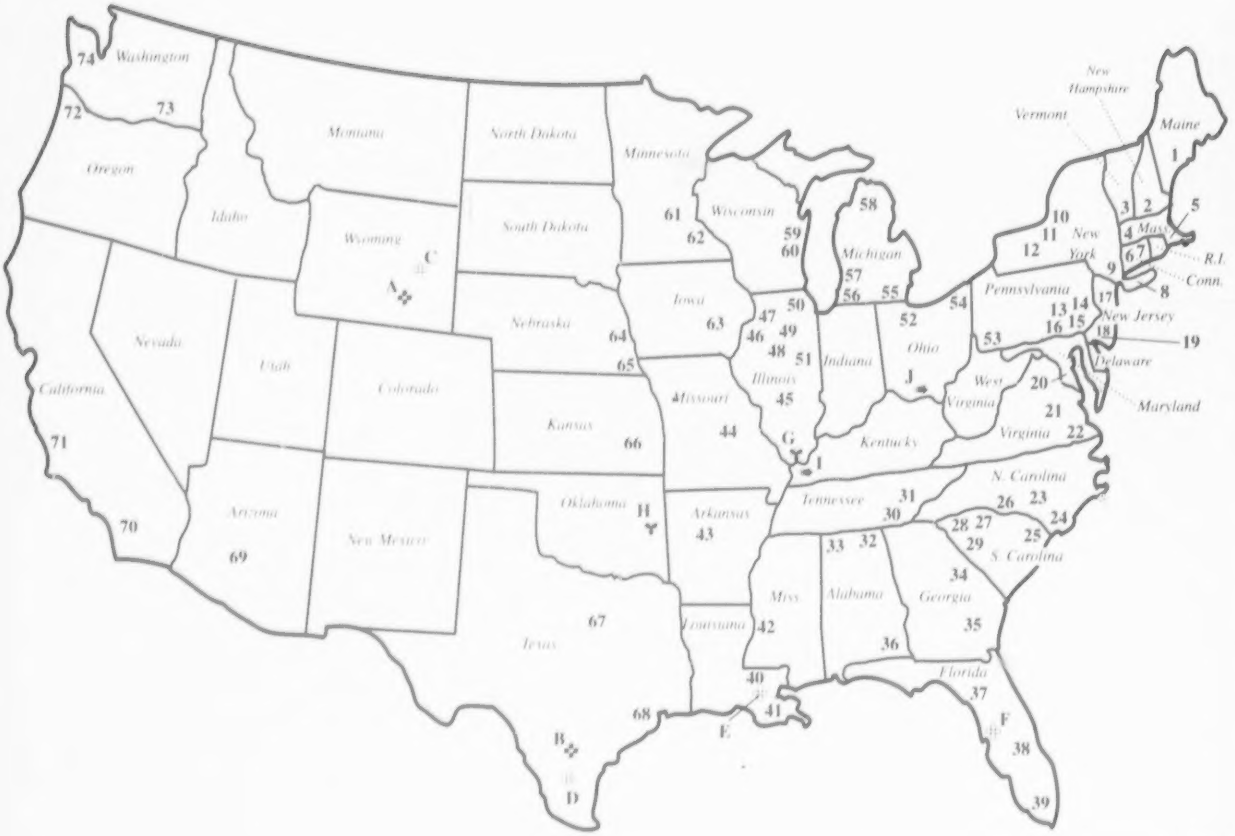
Figure 56
LICENSED NUCLEAR POWER STATIONS AND
FUEL CYCLE FACILITIES IN THE UNITED STATES



Legend
Number or symbol indicates location
■ = PWR in commercial operation
□ = PWR under construction or planned
▲ = BWR in commercial operation
△ = BWR under construction or planned
✤ = Uranium Production (conventional)
⊞ = Uranium Production (solution or by-product)
Ɏ = Conversion Plant
➡ = Enrichment Plant

FUEL CYCLE FACILITIES

Key	Company	Location
A ✤	= Pathfinder Mines	Shirley Basin
B ✤	= Chevron Resources Co.	Panna Maria
C ⊞	= Power Resources	Highland
D ⊞	= Uranium Resources	Rosita
E ⊞	= Freeport Uranium	Donaldsville & Uncle Sam
F ⊞	= IMC [1]	New Wales & Plant City
G Ɏ	= Allied Chemical Corp.	Metropolis
H Ɏ	= Sequoyah Fuels Corp.	Gore
I ➡	= Department of Energy	Paducah
J ➡	= Department of Energy	Portsmouth

[1] IMC = International Minerals and Chemical Corporation

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Table 47
NUCLEAR POWER UNITS IN THE USA

Units Licensed for Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Arkansas 1	Entergy Operations	836	PWR	1974	90	6,560
Arkansas 2	Entergy Operations	858	PWR	1980	82	6,148
Arnold 1	Iowa Electric Light & Power Co.	538	BWR	1975	90	4,240
Beaver Valley 1	CAPCO[2]	810	PWR	1976	53	3,796
Beaver Valley 2	CAPCO	833	PWR	1987	94	6,831
Big Rock Point	Consumers Power Co.	67	BWR	1963	85	498
Braidwood 1	Commonwealth Edison Co.	1,120	PWR	1988	51	5,016
Braidwood 2	Commonwealth Edison Co.	1,120	PWR	1988	67	6,530
Browns Ferry 1	Tennessee Valley Authority	1,065	BWR	1974	—	—
Browns Ferry 2	Tennessee Valley Authority	1,065	BWR	1975	40	3,756
Browns Ferry 3	Tennessee Valley Authority	1,065	BWR	1977	—	—
Brunswick 1	Carolina Power & Light Co.	790	BWR	1977	63	4,373
Brunswick 2	Carolina Power & Light Co.	790	BWR	1975	53	3,649
Byron 1	Commonwealth Edison Co.	1,105	PWR	1985	66	6,404
Byron 2	Commonwealth Edison Co.	1,105	PWR	1987	91	8,821
Callaway	Union Electric Co.	1,118	PWR	1984	102	10,003
Calvert Cliffs 1	Baltimore Gas & Electric Co.	825	PWR	1975	76	5,460
Calvert Cliffs 2	Baltimore Gas & Electric Co.	825	PWR	1977	50	3,637
Catawba 1	Duke Power Co.	1,129	PWR	1985	69	6,800
Catawba 2	Duke Power Co.	1,129	PWR	1986	75	7,380
Clinton 1	Illinois Power Co.	946	BWR	1987	73	6,084
Comanche Peak 1	Texas Utilities Electric Co.	1,137	PWR	1990	60	5,932
Cook 1	American Electric Power Co.	1,020	PWR	1975	82	7,287
Cook 2	American Electric Power Co.	1,060	PWR	1978	87	8,116
Cooper	Nebraska Public Power District	764	BWR	1974	71	4,768
Crystal River 3	Florida Power Corp.	821	PWR	1977	76	5,487
Davis-Besse 1	CAPCO	860	PWR	1978	78	5,898
Diablo Canyon 1	Pacific Gas & Electric Co.	1,073	PWR	1985	79	7,419
Diablo Canyon 2	Pacific Gas & Electric Co.	1,087	PWR	1986	81	7,752

[1] COD = Commercial Operation Date

[2] CAPCO = Central Area Power Coordinating Group

Table 47
NUCLEAR POWER UNITS IN THE USA
(Continued)

Units Licensed for Operation
(Continued)

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Dresden 2	Commonwealth Edison Co.	772	BWR	1970	45	3,040
Dresden 3	Commonwealth Edison Co.	773	BWR	1971	39	2,645
Farley 1	Southern Company Services	824	PWR	1977	76	5,487
Farley 2	Southern Company Services	830	PWR	1981	93	6,785
Fermi 2	Detroit Edison Co.	1,093	BWR	1988	65	6,221
Fitzpatrick	New York Power Authority	757	BWR	1975	51	3,365
Fort Calhoun 1	Omaha Public Power District	478	PWR	1974	78	3,279
Ginna 1	Rochester Gas & Electric Corp.	470	PWR	1970	85	3,509
Grand Gulf 1	Entergy Operations	1,142	BWR	1985	91	9,135
Haddam Neck	Northeast Utilities	565	PWR	1968	75	3,724
Harris 1	Carolina Power & Light Co.	860	PWR	1987	81	6,076
Hatch 1	Southern Company Services	757	BWR	1975	72	4,745
Hatch 2	Southern Company Services	768	BWR	1979	74	4,957
Hope Creek 1	Public Service Electric & Gas	1,031	BWR	1986	83	7,455
Indian Point 2	Consolidated Edison Co. New York	864	PWR	1974	51	3,866
Indian Point 3	New York Power Authority	965	PWR	1976	86	7,233
Kewaunee	Wisconsin Public Service Corp.	503	PWR	1974	84	3,704
La Salle 1	Commonwealth Edison Co.	1,036	BWR	1984	75	6,810
La Salle 2	Commonwealth Edison Co.	1,036	BWR	1984	95	8,655
Limerick 1	Philadelphia Electric Co.	1,055	BWR	1986	88	8,125
Limerick 2	Philadelphia Electric Co.	1,055	BWR	1990	77	7,120
Maine Yankee	Yankee Atomic Group[2]	810	PWR	1972	87	6,187
McGuire 1	Duke Power Co.	1,129	PWR	1981	69	6,830
McGuire 2	Duke Power Co.	1,129	PWR	1984	88	8,700
Millstone 1	Northeast Utilities	654	BWR	1971	31	1,794
Millstone 2	Northeast Utilities	863	PWR	1975	52	3,959
Millstone 3	Northeast Utilities	1,142	PWR	1986	29	2,911
Monticello	Northern States Power Co.	536	BWR	1971	77	3,614
Nine Mile Point 1	Niagara Mohawk Power Corp.	610	BWR	1969	72	3,839
Nine Mile Point 2	Niagara Mohawk Power Corp.	1,072	BWR	1988	71	6,691

[1] COD = Commercial Operation Date

[2] Consists of Maine Yankee Atomic Power Company, Vermont Yankee Nuclear Power Corporation, Public Service Company of New Hampshire, and Yankee Atomic Electric Company.

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Table 47
NUCLEAR POWER UNITS IN THE USA
(Continued)

Units Licensed for Operation
(Continued)

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
North Anna 1	Virginia Electric Power Co.	915	PWR	1978	71	5,662
North Anna 2	Virginia Electric Power Co.	915	PWR	1980	96	7,731
Oconee 1	Duke Power Co.	846	PWR	1973	81	6,040
Oconee 2	Duke Power Co.	846	PWR	1974	100	7,425
Oconee 3	Duke Power Co.	846	PWR	1974	76	5,606
Oyster Creek 1	GPU Nuclear Corp.	620	BWR	1969	54	2,960
Palisades	Consumers Power Co.	730	PWR	1971	77	4,921
Palo Verde 1	Arizona Public Service Co.	1,221	PWR	1986	88	9,451
Palo Verde 2	Arizona Public Service Co.	1,221	PWR	1986	79	8,401
Palo Verde 3	Arizona Public Service Co.	1,221	PWR	1988	72	7,666
Peach Bottom 2	Philadelphia Electric Co.	1,051	BWR	1974	55	5,074
Peach Bottom 3	Philadelphia Electric Co.	1,035	BWR	1974	56	5,100
Perry 1	CAPCO[2]	1,141	BWR	1987	90	9,043
Pilgrim 1	Boston Edison Co.	670	BWR	1972	58	3,420
Point Beach 1	Wisconsin Electric Power Co.	485	PWR	1970	86	3,638
Point Beach 2	Wisconsin Electric Power Co.	485	PWR	1972	87	3,696
Prairie Island 1	Northern States Power Co.	503	PWR	1973	92	4,043
Prairie Island 2	Northern States Power Co.	500	PWR	1974	101	4,480
Quad Cities 1	Commonwealth Edison Co.	769	BWR	1973	52	3,537
Quad Cities 2	Commonwealth Edison Co.	769	BWR	1973	78	5,238
River Bend 1	Gulf States Utilities Co.	936	BWR	1986	84	6,858
Robinson 2	Carolina Power & Light Co.	665	PWR	1971	83	4,821
Salem 1	Public Service Electric & Gas	1,106	PWR	1977	70	6,822
Salem 2	Public Service Electric & Gas	1,106	PWR	1981	79	7,651
San Onofre 1	Southern California Edison Co.	436	PWR	1968	54	2,077
San Onofre 2	Southern California Edison Co.	1,070	PWR	1983	62	5,832
San Onofre 3	Southern California Edison Co.	1,080	PWR	1984	93	8,755
Seabrook	Yankee Atomic Group[3]	1,150	PWR	1990	67	6,794

[1] COD = Commercial Operation Date

[2] CAPCO = Central Area Power Coordinating Group

[3] Consists of Maine Yankee Atomic Power Company, Vermont Yankee Nuclear Power Corporation, Public Service Company of New Hampshire, and Yankee Atomic Electric Company.

Table 47
NUCLEAR POWER UNITS IN THE USA
(Continued)

Units Licensed for Operation
(Continued)

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Sequoyah 1	Tennessee Valley Authority	1,148	PWR	1981	72	7,223
Sequoyah 2	Tennessee Valley Authority	1,148	PWR	1982	92	9,254
South Texas 1	Houston Lighting & Power Co.	1,250	PWR	1988	67	7,283
South Texas 2	Houston Lighting & Power Co.	1,250	PWR	1989	67	7,316
St. Lucie 1	Florida Power & Light Co.	839	PWR	1976	80	5,861
St. Lucie 2	Florida Power & Light Co.	839	PWR	1983	102	7,492
Summer	South Carolina Electric & Gas	885	PWR	1984	69	5,386
Surry 1	Virginia Electric Power Co.	781	PWR	1972	97	6,640
Surry 2	Virginia Electric Power Co.	781	PWR	1973	59	4,023
Susquehanna 1	Pennsylvania Power & Light Co.	1,032	BWR	1983	97	8,784
Susquehanna 2	Pennsylvania Power & Light Co.	1,038	BWR	1985	77	7,027
Three Mile Island 1	GPU Nuclear Corp.	808	PWR	1974	82	5,774
Trojan	Portland General Electric Co.	1,095	PWR	1976	16	1,522
Turkey Point 3	Florida Power & Light Co.	666	PWR	1972	23	1,342
Turkey Point 4	Florida Power & Light Co.	666	PWR	1973	14	822
Vermont Yankee	Yankee Atomic Group[2]	504	BWR	1972	94	4,145
Vogtle 1	Southern Company Services	1,083	PWR	1987	79	7,539
Vogtle 2	Southern Company Services	1,083	PWR	1989	94	8,946
Waterford 3	Entergy Operations	1,075	PWR	1985	78	7,299
WNP 2	WPPSS[3]	1,095	BWR	1984	45	4,280
Wolf Creek	Kansas Gas & Electric Co.	1,135	PWR	1985	60	5,932
Yankee Rowe	Yankee Atomic Group	167	PWR	1961	69	1,016
Zion 1	Commonwealth Edison Co.	1,040	PWR	1973	47	4,287
Zion 2	Commonwealth Edison Co.	1,040	PWR	1974	57	5,150
TOTAL		**99,326**		***(1991 Average:***	***71)***[4]	**616,237**

[1] COD = Commercial Operation Date

[2] Consists of Maine Yankee Atomic Power Company, Vermont Yankee Nuclear Power Corporation, Public Service Company of New Hampshire, and Yankee Atomic Electric Company.

[3] Washington Public Power Supply System

[4] Average does not include those units that entered commercial operation or were retired during 1991.

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Table 47
NUCLEAR POWER UNITS IN THE USA
(Continued)

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	Percent Complete[1]	COD[2]
Comanche Peak 2	Texas Utilities Electric Co.	1,150	PWR	86	1992
Watts Bar 1	Tennessee Valley Authority	1,177	PWR	100	1992
TOTAL		**2,327**			

Indefinitely Deferred

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	Percent Complete[1]	COD[2]
Bellefonte 1	Tennessee Valley Authority	1,213	PWR	89	Indefinite
Bellefonte 2	Tennessee Valley Authority	1,213	PWR	58	Indefinite
Perry 2	CAPCO[3]	1,205	BWR	57	Indefinite
Shoreham	Long Island Lighting Co.	809	BWR	100	Indefinite
Watts Bar 2	Tennessee Valley Authority	1,177	PWR	85	Indefinite
WNP 1	WPPSS[4]	1,250	PWR	65	Indefinite
WNP 3	WPPSS	1,240	PWR	75	Indefinite
TOTAL		**9,357**			

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[1] Source: *Nuclear News*

[2] COD = Commercial Operation Date (expected)

[3] CAPCO = Central Area Power Coordinating Group

[4] WPPSS = Washington Public Power Supply System

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SOUTH AMERICA

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ARGENTINA

Argentina's two operating reactors displayed much improved performance during 1991. The two reactors account for only seven percent of the country's generating capacity, but generated over 7,200 GWh of electricity in 1991, contributing a record 17.1-percent share of total electricity generation in Argentina. Atucha 1, a 335-MWe heavy water reactor achieved a capacity factor of 92 percent during the year. This is a dramatic improvement over its 53 percent capacity factor in 1990 and zero electricity production in 1989. Argentina's other reactor, Embalse, a 600-MWe CANDU reactor, also boosted its performance from 1990, achieving an 86 percent capacity factor (**Table 48**). Both units had suffered operational problems the previous two years and had been shut down frequently for repairs.

A third reactor is under construction in Argentina. Atucha 2, a 692-MWe HWR, is approximately 72-percent complete and scheduled to reach commercial operation in 1996. The reactor was originally scheduled for operation in 1987, but design changes and severe financial constraints have delayed its progress. An agreement finalized in 1990 with the German government will provide matching-fund loans to Argentina to continue the construction. An estimated US$1.4 billion will be required to complete Atucha 2.

Argentina made important progress in the area of non-proliferation and nuclear safeguards in 1991. In April, Argentina's foreign minister stated that the government would soon take steps toward ratifying the Treaty for the Prohibition of Nuclear Weapons in Latin America (Tlatelolco Treaty). Argentina has signed, but not ratified, the treaty, and thus is not yet bound by its terms. In July, the presidents of Argentina and Brazil signed an accord outlining their mutual agreement on the peaceful uses of nuclear energy. The agreement outlines specific measuring systems for the accounting of nuclear-related material. It builds on a 1990 agreement which placed each country's nuclear facilities under International Atomic Energy Agency (IAEA) safeguards and opened the facilities to inspection by each country. On December 13, 1991, Argentine President Carlos Menem witnessed the signing of a draft safeguards agreement with the IAEA confirming the earlier accord. The agreement is compatible with the Tlatelolco Treaty and likely will lead to the implementation of full IAEA non-proliferation safeguards.

FUEL CYCLE DEVELOPMENTS

Early in 1991, management of the country's two operating reactors was transferred to the Argentine Energy Ministry. Previously, all nuclear operations had been controlled by the Comisión Nacional de Energía Atómica (CNEA). The transfer of responsibility was made as part of a program to streamline inefficient state industries. The Energy Ministry will be responsible for the two operating reactors; the Economy Ministry will take over supervision of the Atucha 2 construction project; and CNEA will remain responsible for managing the country's fuel-cycle facilities and research reactors.

Argentina has several facilities under construction as part of its plan to provide for full domestic fuel-cycle capability. CNEA operates a 40 thousand SWU-per-year gaseous diffusion enrichment plant at Pilcaniyeu. It has plans to expand the plant's capacity to 100 thousand SWU annually, but budget cuts have delayed the expansion. Argentina also has a heavy water plant under construction. The plant, located at Arroyito, has a planned capacity of 250 tons per year, but has been delayed repeatedly due to the country's economic problems. A Zircaloy fuel fabrication plant and a pilot reprocessing facility also are under construction at Ezeiza, although both have been delayed due to financial limitations.

Since 1985, more than enough uranium to operate Argentina's reactors has been produced by the country's domestic uranium mines; total uranium production exceeds five million pounds equivalent U_3O_8, whereas lifetime reactor requirements thus far total only about three million pounds. Argentina's only operating uranium facility is the San Rafael mine located in the Sierra Pintada district. Production at the La Estela mine ceased in 1990.

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Table 48
NUCLEAR POWER UNITS IN ARGENTINA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Atucha 1	Energy Ministry	335	HWR	1974	92	2,693
Embalse	Energy Ministry	600	HWR	1984	86	4,535
TOTAL		**935**		*(1991 Average:* **88***)*		**7,228**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	Projected COD	Percent Complete[2]
Atucha 2	Economy Ministry	692	HWR	1996	73

[1] COD= Commercial Operation Date

[2] Source: *Nuclear News*

The country has more than 30 million pounds equivalent U_3O_8 of reasonably assured reserves still unrecovered. Concentrates are converted to UO_2 at a plant near Cordoba, which has a two-line capacity of 300 tons per year. Conversion to UF_6 and enrichment to 0.85 percent ^{235}U occurs at the Pilcaniyeu facility.

Argentina is continuing to pursue its goal to be a nuclear power leader in Latin America and among developing nations. It has developed reactor designs for domestic and export use and has actively marketed them abroad. In 1990, Argentina and Turkey formed a joint architectural/engineering firm to develop Argentina's 25-MWe Carem-15 light water reactor. In 1991, the joint-venture began to negotiate the contracts for the engineering and construction of two Carem reactors, one to be located in Argentina, the other in Turkey. A final agreement has not been reached, although both sides have agreed to subject the facilities and the technology transfers to IAEA safeguards.

President Menem continues to support nuclear power and the government's commitment to self-sufficiency in the nuclear fuel cycle. The government plans to use nuclear power to alleviate the severe power shortages of recent years, but the country's economic challenges and foreign debt repayment problems are limiting the government's ability to finance major development projects.

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BRAZIL

Brazil's only operating reactor, Angra 1, a 626-MWe PWR, had a difficult year in 1991, generating 1,374 GWh. Several major outages resulted in a capacity factor of 25 percent. Brazil's primary source of power is hydroelectric generation, which provides about 60 percent of the country's total electrical output. Brazil urgently requires additional electrical capacity, as power shortages are common and over 20 percent of the population has not yet been connected to the country's electricity grid. However, environmental concerns and a vulnerability to droughts is limiting growth of hydroelectric capacity. The country also is reducing its reliance on wood and charcoal fuel for environmental reasons, and plans to turn to natural gas and nuclear. But the country's economic struggles limit these capital-intensive plans.

Brazil does have two other reactors under construction. Angra 2 and 3, both 1,245-MWe PWRs based on a Seimens/Kraftwerk Union design, are scheduled for completion in 1997 and 2001, respectively (**Table 49**). However, severe economic problems, hyperinflation, and excessive foreign debt have slowed the construction progress of the two units. Angra 2 is 64-percent complete (**Figure 57**) and is likely to be completed, but proposed budget cuts by the government had jeopardized its completion. However, the cuts were rescinded, allowing the project to continue. Several times construction ceased due to lack of funds; any available money was used to maintain the equipment. While financial challenges remain, the Brazilian government, with the help of the German government, plans to finish the reactor since all of the components have been delivered to the site and the unit is more than half completed.

The fate of Angra 3 is less certain. It is only 41-percent complete and progress has been very slow. Insufficient money has been budgeted for the unit each year, and many within the government believe construction should cease. One proposal even considered selling the components from Unit 3 that have not yet been installed, and using the money to complete Angra 2. Nevertheless, Unit 3 is still officially scheduled for completion in 2001.

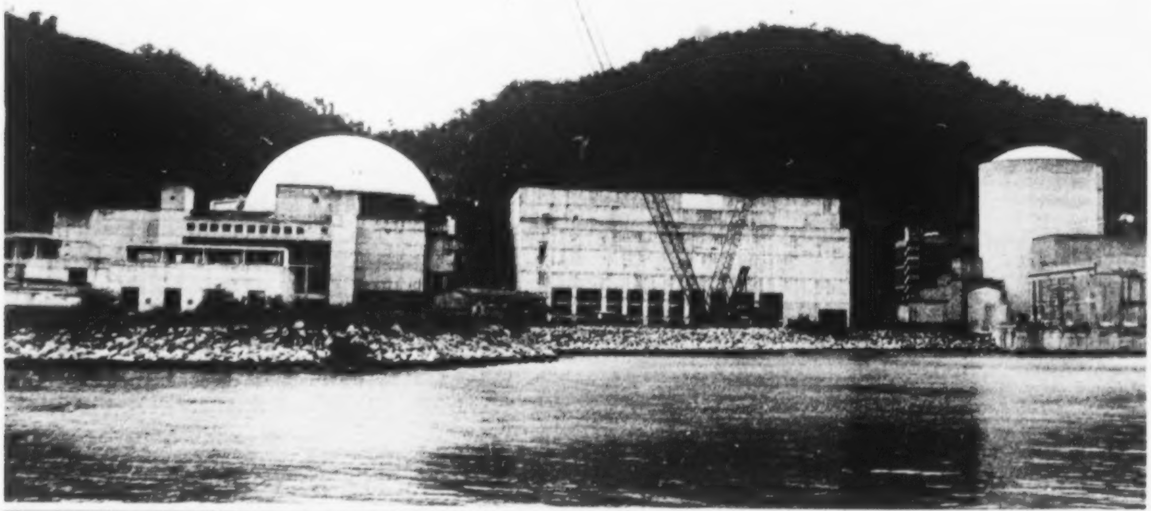

Figure 57 — Angra Nuclear Power Station. Angra 1, a 626-MWe PWR, is on the right, and Angra 2, a 1,245-MWe PWR under construction and 64-percent complete, is on the left. (*Photo courtesy of Furnas*)

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Table 49
NUCLEAR POWER UNITS IN BRAZIL

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1991 Capacity Factor (percent)	Total 1991 Electricity Generation (GWh net)
Angra 1	Furnas[2]	626	PWR	1984	25	1,374

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	Projected COD	Percent Complete[3]
Angra 2	Furnas	1,245	PWR	1997	64
Angra 3	Furnas	1,245	PWR	2001	41
TOTAL		**2,490**			

[1] COD= Commercial Operation Date

[2] Furnas = Furnas Centrais Elétricas SA

[3] Source: *Nuclear News*

Although Brazil has not signed the Treaty on the Non-Proliferation of Nuclear Weapons, it did make significant progress in the area of non-proliferation and nuclear safeguards in 1991. In July, the presidents of Brazil and Argentina signed an accord outlining their mutual agreement on the peaceful uses of nuclear energy. The treaty outlines specific measuring systems for the accounting of nuclear-related material. This agreement follows an agreement reached in 1990 with Argentina to open each country's nuclear facilities to IAEA safeguards and to one another for inspection. In December, Brazilian President Fernando Collor witnessed the signing of a draft safeguards agreement with the IAEA confirming the July accord. The agreement is compatible with the treaty prohibiting nuclear weapons in Latin America (Tlatelolco Treaty) and likely will lead to implementation of full IAEA non-proliferation safeguards in the future.

FUEL CYCLE

Brazil has few fuel cycle facilities. The military formerly had tremendous influence on the country's nuclear program, but President Collor has moved aggressively to end military application of nuclear technology. Brazil has a small enrichment facility at Rezende that has been shut down, and a small gas ultracentrifuge enrichment plant located at Ipero with a capacity of 1,000 SWU per year. The military had proposed dramatically increasing the Ipero plant's capacity, but with diminished influence of the military and the country's economic challenges, the expansion of this plant in the near future is unlikely. Any future development of fuel cycle facilities will be affected by the country's moves toward adherence to IAEA safeguards.

Brazil has several major uranium deposits located in five primary districts: Central Ceará district; Lagoa Real district; Poços de Caldas district; Seridó district; and the Southeastern Paraná Basin. As a whole, Brazil has an estimated 600 million pounds equivalent U_3O_8 in reserves. At present, the Poços de Caldas district has the only active uranium production; the Cercado open-pit mine in that district produced more than 240 thousand pounds equivalent U_3O_8 in 1991. Brazil's state-owned uranium production and processing company, Urânio do Brasil, announced it has decided to begin shifting its production from Poços de Caldas to lower-cost reserves at Lagoa Real. Production at Lagoa Real is expected to begin in 1993.

GLOSSARY

ACRONYM/NAME	MEANING	COUNTRY
ABB	Asea-Brown Boveri	Sweden/Switzerland
ABB-CE	ABB-Combustion Engineering	USA
AEC	Atomic Energy Commission/Atomic Energy Corporation	various/S. Africa
AECB	Atomic Energy Control Board	Canada
AECL	Atomic Energy of Canada, Ltd.	Canada
AEE	Atomenergoexport	Russia
AGR	Advanced gas cooled reactor	universal
ANDRA	State agency responsible for spent fuel and radioactive waste management	France
ATR	Advanced thermal reactor	universal
AVLIS	Atomic vapor laser isotope separation	USA
BAG	Bayernwerk AG	Germany
BATAN	Indonesian National Atomic Energy Agency	Indonesia
BKW	Bernische Kraftwerk AG	Switzerland
BMFT	Bundesministerium für Forschung und Technologie	Germany
BNFL	British Nuclear Fuels plc	UK
BP	British Petroleum	UK
BW/EVS	Badenwerk AG/Energieversorgung Schwaben AG	Germany
BWR	Boiling water reactor	universal
B&W	Babcock & Wilcox	USA
CANDU	Canadian deuterium uranium (heavy water reactors)	Canada
CAPCO	Central Area Power Coordinating Group	USA
CEA	Commisariat à l'Energie Atomique	France
CEGB	Central Electricity Governing Board	UK
CEZ	Česke Energetické Závody	CSFR
CFE	Comisión Federal de Electricidad	Mexico
CGE	Compagnie Générale d'Electricité	France
CIS	Commonwealth of Independent States	CIS
CNEA	Comisión Nacional de Energia Atomica	Argentina
CNEIC	China Nuclear Energy Industry Corporation	China
CNNC	China National Nuclear Corporation	China
COD	Commercial operation date	universal
Codesa	Convention for a Democratic South Africa	South Africa
Cogema	Compagnie Générale des Matières Nucléaires	France
Comuf	Compagnie des Mines d'Uranium de Franceville	Gabon
Cominak	Compagnie Minière d'Akouta	Niger
CRISLA	Chemical reaction by isotope selective laser activation	Canada/USA
CSFR	Czech and Slovak Federal Republic (formerly Czechoslovakia)	CSFR
CSUP	Československý Uránový Průmysl, Koncern	CSFR
DOE	United States Department of Energy	USA
EAR	Estimated additional resources	universal
EC	European Community	Europe
EdF	Electricité de France	France
EEC	European Economic Community	Europe
EIS	Environmental impact statement	universal

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Glossary *(continued)*

ACRONYM/NAME	MEANING	COUNTRY
Electrabel	Belgian utility formed in 1990 by the merger of UNERG, INTERCOM, and EBES	Belgium
ENEL	Ente Nazionale per l'Energia Elettrica	Italy
ENUSA	Empresa Nacional del Uranio S.A.	Spain
EPC	{*preface*} Electric Power Corporation (*example*: Kansai EPC)	universal
EPDC	Electric Power Development Corporation	Japan
ERA	Energy Resources of Australia	Australia
ERGO	East Rand Gold and Uranium Company, Ltd.	South Africa
Eurodif	A European uranium enrichment consortium	Europe
EUP	Enriched uranium product (in the form of uranium hexafluoride)	universal
FBFC	Franco Belge de Fabrication de Combustibles	France
FBR	Fast breeder reactor	universal
FEARO	Federal Environmental Assessment Review Office	Canada
FERC	Federal Energy Regulatory Commission	USA
FITCO	Fuel International Trading Corporation	USA/France
Freegold	Formerly Free State Joint Metallurgical Scheme	South Africa
FURC	Freeport Uranium Recovery Company	USA
Furnas	Furnas Centrais Elétricas SA	Brazil
GCR	Gas-cooled reactor	universal
GDP	Gaseous-diffusion plant	universal
GE	General Electric Corporation	USA
GKN	Gemeinschaftskernkraftwerk Neckar GmbH	Germany
GKT	Gemeinschaftskaftwerk Tullnerfeld GmbH	Austria
GNSS	Global Nuclear Services and Supply	USA/Russia/Switz.
HEW	Hamburgische Elektricitätswerke AG	Germany
HLW	High-level waste	universal
HTGR	High temperature gas cooled reactor	universal
HWR	Heavy water reactor	universal
IAEA	International Atomic Energy Agency	international
ILW	Intermediate-level waste	universal
IMC	International Minerals and Chemical Corporation	USA
INPO	Institute of Nuclear Power Operators	USA
ISL	In-situ leaching	universal
ITC	International Trade Commission	USA
IVO	Imatran Voima Oy	Finland
JAPC	Japan Atomic Power Corporation	Japan
KEPCO	Korea Electric Power Company	South Korea
Kg	Kilogram	universal
KgU	Kilogram of uranium	universal
KKG	Kernkraftwerk Gösgen-Däniken AG	Switzerland
KKL	Kernkraftwerk Leibstadt AG	Switzerland
KKP	Kernkraftwerk Philippsburg GmbH	Germany
KNFC	Korea Nuclear Fuel Company	Korea
KWO	Kernkraftwerk Obrigheim GmbH	Germany
KWU	Kraftwerk Union AG	Germany
LES	Louisiana Energy Systems	USA
LILCO	Long Island Lighting Company	USA
LLW	Low-level waste	universal

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Glossary *(continued)*

ACRONYM/NAME	MEANING	COUNTRY
LMFBR	Liquid-metal-cooled fast breeder reactor	universal
LWR	Light water reactor	universal
MAEI	Ministry of Atomic Energy and Industry of the former Soviet Union	Soviet Union
Minatom	Ministry of Atomic Energy of the Russian Federation	Russia
MITI	Ministry of International Trade and Industry	Japan
MOX	Mixed oxide fuel	universal
MRS	Monitored retrievable storage	USA/universal
MT	Metric tonne(s) (1,000 kilograms per tonne)	universal
MTHM	Metric tonne(s) heavy metal	universal
MTU	Metric tonne(s) uranium	universal
MVMT	Magyar Villamos Müvek Tröszt (Hungarian Electricity Board)	Hungary
NDP	New Democratic Party	Canada
NE	Nuclear Electric	UK
NEK	Nuklearna Elektrarna Krško (a Slovenian/Croatian consortium)	Slovenia
NOK	Nordostschweizerische Kraftwerke AG	Switzerland
NPOC	Nuclear Power Oversight Committee	USA
NPC	Nuclear Power Corporation (under India's Department of Atomic Energy)	India
NPT	Treaty for the Non-Proliferation of Nuclear Weapons	international
NRC	Nuclear Regulatory Agency	USA
NUEXCO	Name of the former Nuclear Exchange Corporation	USA
NUFCOR	Nuclear Fuels Corporation of South Africa Pty. Limited	South Africa
OKG	OKG Aktiebolag	Sweden
Onarem	Office Nationale des Ressources Minières	Niger
OSART	Operational Safety Review Team of the IAEA	International
OURD	Overseas Uranium Resources Development Company	Japan
OVEC	Ohio Valley Electric Corporation	USA
PAV	Paksi Atomerőmű Vállalat	Hungary
PHWR	Pressurized Heavy Water Reactor	universal
PMC	Palabora Mining Corporation	South Africa
PNC	Power Reactor and Nuclear Development Corporation	Japan
PowerGen	A British electric utility (non-nuclear)	UK
PREAG	PreussenElektra AG	Germany
PRI	Power Resources, Inc.	USA
PUHCA	Public Utility Holding Company Act	USA
PURPA	Public Utilities Regulatory Policy Act	USA
PVO	Perusvoima Oy (a consortium formed by IVO and TVO)	Finland
PWR	Pressurized Water Reactor	universal
QML	Queensland Mines Ltd.	Australia
RAR	Reasonably assured resources	universal
RBMK	Reaktory Bolshoi Moshchnosti Kanalnye (graphite-moderated, water-cooled)	Europe
RENEL	Regia Autonoma Nationala de Electricite	Romania
RTZ	RTZ Corporation (formerly Rio Tinto Zinc Corporation)	UK
RWE	RWE AG (formerly named Rheinisch-Westfälisches Elektrizitätswerk AG)	Germany
SAE	Société Auxiliare d'Energie	USA
SBH	Siemens Brennelementewerke Hanau	Germany
SBK	Schnell-Brüter Kernkraftwerksgesellschaft mbH	Germany
SENA	Société d'Energie Nucléaire Franco-Belge des Ardennes	France/Belgium

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Glossary *(continued)*

ACRONYM/NAME	MEANING	COUNTRY
SEP	Slovenksý Energetický Podnik, S.P.	CSFR
SEU	State Economic Union	Bulgaria
SFC	Sequoyah Fuels Corporation	USA
SILVA	Séparation isotopique par laser de la vapeur atomique d'uranium (French technology similar to USDOE's AVLIS)	France
SKI	Swedish Nuclear Power Inspectorate	Sweden
SNL	Scottish Nuclear Ltd.	UK
Somaïr	Société des Mines de l'Air	Niger
SSPB	Swedish State Power Board (Vattenfall)	Sweden
SWU	Separative work unit	universal
Sydkraft	Swedish electric utility	Sweden
Synatom	Belgium's nuclear fuel supply company	Belgium
Taipower	Taiwan Electric Power Company	Taiwan
Techsnabexport	(V/O Techsnabexport) Nuclear fuel export trading company of Minatom	Russia
TENEX	Trade name for Techsnabexport	Russia
TEPCO	Tokyo Electric Power Company	Japan
THORP	BNFL's thermal oxide reprocessing plant	UK
TOMIN	US-based subsidiary of Total Minerals	USA
Tlatelolco Treaty	Treaty for the Prohibition of Nuclear Weapons in Latin America	Latin America
TOTAL	Total Compagnie Minière	France
TVA	Tennessee Valley Authority	USA
TVO	Teollisuuden Voima Oy	Finland
UEE	Uranium Enrichment Enterprise	USA
UEM	Uranerz Exploration and Mining, Ltd.	Canada
UF_6	Uranium hexafluoride	universal
UG	Urangesellschaft mbH	Germany
UMETCO	Umetco Minerals Corporation	USA
UO_2	Uranium dioxide	universal
UPR	Formerly Union Pacific Resources	USA
UP3	One of Cogema's nuclear fuel reprocessing plants	France
Urenco	A European uranium enrichment corporation	UK/Neth./Germany
URI	Uranium Resources, Inc.	USA
USC	Utility Services Contract (DOE)	USA
VEAG	Vereinigte Energiewerke AG	Germany
VEW	Vereinigte Elektrizitätswerke Westfalen AG	Germany
VVER	Vodo-Vodyanoi Energetichesky Reaktors (PWR-type)	Europe
WANO	World Association of Nuclear Operators	International
WEPCO	Wisconsin Electric Power Corporation	USA
WIPP	Waste Isolation Pilot Plant	USA
WPPSS	Washington Public Power Supply System	USA

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NUEXCO MARKET VALUES:

DEFINITIONS, DERIVATIONS, AND COMMENTS

DEFINITIONS

- The **Exchange Value** is NUEXCO's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.

- The **UF$_6$ Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.

- The **Loan Rate** is NUEXCO's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.

- The **Conversion Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.

- The **SWU Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of enrichment services could be concluded as of the date indicated.

- The **Transaction Value** is a weighted-average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
  - Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
  - At least ten transactions;
  - Transactions involving a sum total of at least 2 million pounds equivalent U_3O_8.

DERIVATIONS AND COMMENTS

- All **Market Values** are expressed in terms of US$.

- All **Market Values** are based on:
  - Data from recently completed transactions.
  - Data from pending transactions.
  - Firm bids to buy or borrow, and firm offers to sell or lend.
  - Prices purchasers or rates borrowers have expressed a willingness to pay, but for which NUEXCO is not aware of firm bids to buy or borrow and prices sellers or rates lenders have expressed a willingness to accept, but for which NUEXCO is not aware of firm offers to sell or lend.

- Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these **Market Values**.

- In the determination of prices, NUEXCO does not consider charges for transportation other than that customarily provided by suppliers.

- The prices of services or materials delivered under long-term contracts with primary suppliers are not considered in the determination of the listed values.

- For the **SWU Value**, NUEXCO converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight percent ^{235}U and a product assay of 3.0 weight-percent ^{235}U, assuming feed costs corresponding to the NUEXCO **Exchange Value** and **Conversion Value** determined as of the same date.

- In calculating the **Transaction Value**, NUEXCO does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future **Exchange Values** or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it can not currently be determined.

- The sample time for the **Transaction Value** is extended as necessary to satisfy the minima for the number of transactions and quantity of material. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

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NUEXCO

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